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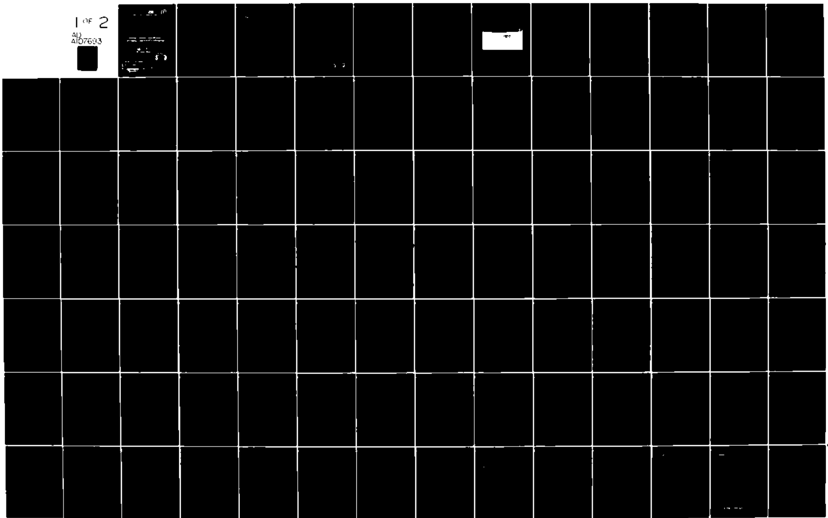

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

26 March 1980

Subject: Main Tailings Dam Phase I Inspection Report

This report presents the results of field inspections and evaluation of the Main Tailings Dam (MO 31082).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District because of the active piping that was visible in the right section of the dam (See photo 12 of the report).

Also, unsafe conditions exist because of the following:

a. A large seepage area observed downstream of the main dam.

b. Four large erosion gullies up to 6 feet deep on the downstream face of the main dam.

c. Old slide (50 feet wide) heavily overgrown observed on the downstream face of the main dam.

For Phase I reports, the extent of the downstream damage zone has been determined assuming that all materials contained by the tailings dam are in a liquid state.

SUBMITTED BY: SIGNED — 22 APR 1980
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 23 APR 1980
Colonel, CE, District Engineer — Date

MAIN TAILINGS DAM
MADISON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31082

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
INTERNATIONAL ENGINEERING COMPANY, INC.
CONSULTING ENGINEERS
SAN FRANCISCO, CALIFORNIA

UNDER DIRECTION OF
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

JUNE 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Main Tailings Dam
State	Missouri
County	Madison
Stream	Toler Creek (Tributary to Saline Creek)
Date of Inspection	28 March 1979

The Main Tailings Dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. of San Francisco, California. The dam is owned by Anschutz Uranium Corporation of Denver, Colorado. The purpose of the inspection was to assess the general condition of the dam with respect to safety. The assessment was based on an evaluation of the available data, a visual inspection and an evaluation of the hydrology and hydraulics of the site to determine if the dam poses hazards to human life or property. The purpose of the dam is to impound lead tailings.

The Main Tailings Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams" furnished by the Department of the Army, Office of the Chief of Engineers. Based on these Guidelines, this dam is classified as small. The U.S. Corps of Engineers has classified it as having a high downstream hazard potential to indicate that failure of this dam could threaten life and property. The damage zone, estimated by the U.S. Corps of Engineers, extends approximately eight miles downstream of the dam. The city of Fredericktown and three state highway bridges are within this damage zone.

The results of the inspection and evaluation indicate that the combined capacity of the spillway and 48-inch diameter concrete outlet does not meet the criteria given in the Guidelines for a dam of the size and hazard potential of Main Tailings Dam. As a small dam with a high hazard potential, it is required by the Guidelines to pass 50 to 100 percent of the Probable Maximum Flood (PMF) without overtopping the crest. The spillway design flood adopted for this dam is 100 percent of the PMF because the consequences of failure are serious since the dam is located about 1/4-mile from a residential area of Fredericktown. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. It was calculated that the spillway and outlet could pass a 100-year flood (a flood having a 1 percent chance of being equalled or exceeded in any 1 year) without overtopping the dam. It was also estimated that the spillway and outlet could pass 38 percent of the PMF without significant erosion of the spillway or embankment. However, estimates indicate that the spillway and outlet cannot pass 50 percent of the PMF without significant erosion of the spillway and embankment.

The spillway should be enlarged and/or the freeboard increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillway and embankment. Adequate erosion protection should be provided in the spillway so that it can withstand the peak discharge velocity resulting from the PMF. Erosion protection should also be provided on the upstream and downstream faces of the dam.

Seepage and stability analyses of this dam are not available. These studies should be performed by a professional engineer experienced in the design and construction of tailings dams. The necessary data for these analyses would be obtained from additional investigations. The investigations should consist of field exploration, soil sampling, and a laboratory testing program to obtain the engineering parameters necessary for the analyses.

Remedial work should be performed under the direction of a professional engineer experienced in the design and construction of tailings dams. Specific remedial work should be addressed to controlling piping of tailings through the dam. The dam could become unstable if the impounded water reached a sufficient depth to accelerate the piping. Small trees should be removed to prevent possible seepage. Also, the erosion gullies in the embankment should be repaired.

An inspection and maintenance program should be initiated. Periodic inspections should be made and documented by qualified personnel to observe the performance of the dam, spillway and outlet.

It is recommended that the owner take action to correct the deficiencies described.

Kenneth B. King

Kenneth B. King, P.E.

Michael P. Forrest

Michael P. Forrest, P.E.

Donald R. Sanders

Donald R. Sanders, R.G.

OVERVIEW OF THE DOWNSTREAM FACE OF THE MAIN TAILINGS DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MAIN TAILINGS DAM
I.D. NO. 31082

TABLE OF CONTENTS

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

APPENDIX B

INFORMATION SUPPLIED BY OTHERS

LIST OF PLATES

PHOTOGRAPHS

Photograph Record and Photographs (No. 1 through No. 14)

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
MAIN TAILINGS DAM - ID NO. 31082

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspections of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Main Tailings Dam be made and authorized International Engineering Company, Inc. to make the inspection.

b. Purpose of the Inspection. The purpose of the inspection was to assess the general condition of the dam with respect to safety, based on available data and visual inspection, to determine if the dam poses hazards to human life or property.

d. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These Guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) Main Tailings Dam is an earthfill dam that is used to impound lead tailings, which consist of loose, saturated fine sand. The dam consists of a lower (main) embankment and an upper (secondary) embankment.

(2) The spillway is an open channel that is located at the left abutment. It is approximately 2.5 feet deep and 15 feet wide, and sandy gravelly clay is exposed in the channel. A decant outlet pipe is located at the right abutment. This concrete outlet pipe is 48 inches in diameter and about 850 feet long.

b. Location. The dam is located in the northeast portion of Madison County, Missouri, as shown on Plate 1. The vicinity of the dam is shown in Plate 2. The Main Tailings Dam is located in Section 16, Township 33 North, Range 7 East.

c. Size Classification. This dam is less than 40 feet high and the impoundment storage is less than 1,000 acre-feet; therefore, this dam is classified as small in size, according to the "Recommended Guidelines for Safety Inspection of Dams".

d. Hazard Classification. The U.S. Corps of Engineers has classified this dam in the high hazard potential category. The estimated damage zone, as provided by the Corps of Engineers, extends approximately eight miles downstream of the dam. The city of Fredericktown and three state highway bridges are within this distance.

e. Ownership. This dam is owned by:

Anschutz Uranium Corporation
2400 Anaconda Tower
555 17th Street
Denver, Colorado 80202

f. Purpose of Dam. The purpose of the dam is to impound lead tailings.

g. Design and Construction History. No design or construction data are available. The date of construction also was not available. A report by C. J. Stohr of the Missouri Geology and Land Survey, dated 15 November 1977, states that the dam was breached in the 1950's and was rebuilt. The dam failed by overtopping on 28 March 1977, and the structure has been repaired. The following references document the 1977 failure and other information. These reports were prepared by personnel from the Missouri Geology and Land Survey, Applied Engineering and Urban Geology; more detailed documentation is presented in Section 2.

Report by T. J. Dean, 30 March 1977.
Report by C. J. Stohr, 15 November 1977.
Report by J. H. Williams, 14 February 1978.

National Lead Industries was the owner of the property and dam in 1977. The property was then sold to Mr. Silas Dees of Madison County who in turn sold it to Nedlog Corporation of Colorado. Anschutz Uranium Corporation purchased the property from Nedlog in March 1979, approximately two weeks prior to the Phase I Inspection.

h. Normal Operating Procedures. Excess storm runoff passes through an uncontrolled spillway and the 48-inch diameter outlet pipe. These structures do not require operation, and no records of operation are known to exist. Since tailings are no longer conveyed to the impoundment, the dam is inactive.

1.3 PERTINENT DATA

Field surveys were made by Booker Associates, Inc. of St. Louis, Missouri on 4 April 1979. The survey data are presented in Plates 3 through 6.

a. Drainage Area - 459 acres (Topographic Quadrangle, 1:24,000 scale, Fredericktown, SE Mo., AFC unedited advance print, 1977).

b. Discharge at Damsite.

(1) Approximate combined discharge of spillway and outlet pipe for pool at top of dam (El. 835.7) - 500 cfs.

(2) Maximum experienced outflow at damsite - No available information.

c. Elevation (Feet Above M.S.L.)1/

(1) Top of dam - Varies from El. 835.7 to El. 843.5.

(2) Streambed at downstream toe of dam - El. 802 ± feet.

(3) Tailings level adjacent to dam - Varies from El. 831 ± to El. 837 ±.

(4) Spillway crest - El. 833.0 feet.

(5) Intake structure -

(a) Top stop-log - El. 830.24.

(b) Concrete sill - El. 830.93.

d. Reservoir. Length of impoundment - 2000 ± feet (Topographic Quadrangle, 1:24,000 scale, Fredericktown, SE Mo., AFC *unedited advance* print, 1977).

e. Storage.

(1) Top of dam (El. 835.7) - 557 acre-feet.

(2) Spillway crest (El. 833.0) - 453 acre-feet.

f. Reservoir Surface Area.

(1) Top of dam (El. 835.7) - 43.5 acres.

(2) Spillway crest (El. 833.0) - 38.0 acres.

g. Dam.

(1) Type - Earthfill.

(2) Length - 1900 feet ±.

1/ Elevations are based on a reference datum of 845.00 feet M.S.L. at the temporary bench mark (see Plate 3). This elevation was estimated from the topographic quadrangle.

(3) Height (maximum above streambed) - 35 feet±.

(4) Top width - The crest width of the secondary dam varies from 9 to 12 feet.

(5) Side slopes -

(a) Downstream slope - approximately 1.7(H) to 1.0(V).

(b) Upstream slope - between 1.5(H) and 1.0(H) to 1.0(V), approximately.

(6) Zoning - The main dam consists of brown sandy, clayey soil. The secondary dam appears to be constructed primarily of fine sand tailings. Brown gravelly clay overlies the crest. The 300-foot long plug was constructed of brown gravelly clay.

(7) Cutoff - There is no information available that pertains to the design or construction of a cutoff.

h. Spillway.

(1) Type - Uncontrolled open channel on the left abutment.

(2) Control section - Trapezoidal section, 15-foot bottom width, 2.6-foot depth and 49-foot top width.

(3) Crest elevation - El. 833.0 M.S.L.

(4) Upstream channel - There is no upstream channel.

(5) Downstream channel - Shallow cut.

i. Outlets.

(1) Type of outlet - 48-inch diameter concrete pipe (with bell-and-spigot joints) which is connected to a vertical intake structure located near the right abutment.

(2) Length - Approximately 850 feet.

(3) Invert of pipe at intake structure - El. 819.53 feet.

(4) Invert of pipe at downstream end - El. 817.58 feet.

j. Diversion Ditches. The principal spillway for the Upstream Dam (I.D. No. 31080) extends from the Upstream Dam to the area downstream of the spillway channel of the Main Tailings Dam and acts as a diversion ditch for the tailings impoundment. The channel is approximately U-shaped and varies from 8 to 10 feet in depth.

k. Regulating Outlets. None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No design drawings or data were available.

2.2 CONSTRUCTION

No construction data were available. However, reports of a failure that were made available to the inspection team are referenced below and are in Appendix B. The dam was breached in the 1950's and was rebuilt (2). The dam failed on 28 March 1977 (1,4). The report by Dean (1) states that the secondary dam failed first by overtopping, and the main structure was then breached. High intensity rainfall of about 6 inches and high winds caused overtopping of the secondary dam, which was founded on "fill material in the stilling basin" (1). Dean recommended that a hydrologic evaluation of the impoundment and spillway system be made to prevent future incidence of overtopping. Dean also stated that erosion had occurred at the adjacent spoil piles and that eroded materials had washed into the impoundment and reduced its water storage capacity. The secondary dam did not appear to be designed, constructed, or maintained for long-term use, according to this report.

The report by Stohr (2) describes the dam as consisting of "an earthen embankment overgrown with trees and brush, and a dike composed principally of tailings". The breach caused by the 1977 failure at the main dam was repaired with fill consisting of "stoney clay which was quite soft" (2). A report by Williams (3) indicates that the breach was filled with tailings and soil and that, in February 1978, cracks were developing in the fill. At the time of Stohr's inspection, slight flow of water from an 8-inch diameter pipe was observed, but the upstream end of the pipe

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[1] Dean, T. J., "Report of the National Lead Stilling Basin Washout, Madison County, Missouri", Applied Engineering and Urban Geology, Geology and Land Survey, 30 March 1977.

[2] Stohr, C. J., "Engineering Geologic Report on the Silas Dees (Formerly National Lead Tailings) Ponds, Madison County, Missouri", Applied Engineering and Urban Geology, Geology and Land Survey, 15 November 1977.

[3] Williams, J. H., "Addendum to Fredricktown, nee (sic) National Lead, nee (sic) Dees Tailings Dam, Madison County, Missouri", Applied Engineering and Urban Geology, Geology and Land Survey, 14 February 1978.

[4] Ashcroft, John, (Attorney General) letter to National Lead Industries concerning failure of the tailings dam, 5 April 1977.

could not be found. Williams states that the 8-inch diameter pipe was placed end-to-end and was not coupled; also, water was seeping around the pipe. Two areas of ponded water were reported immediately upstream of the main dam (2). One of the ponds was discharging water over the downstream face of the dam. The tailings impounded by the secondary dam were not filled in with soil, so that the gap formed by the breach in the tailings was filled with water. Also, the decant structure was filled with debris. Stohr concluded that there were indications of a lack of use of acceptable construction practices in rebuilding the dam and that another failure of this dam "seems imminent". It was recommended that an engineer experienced in dam design and construction be consulted. The Williams report mentioned two potential hazards: the fill across the gorge formed by the 1977 breach might collapse and cause the structure to fail again, and the plugged decant structure could cause the dam to fail.

2.3 OPERATION

No records of operation are known to exist.

2.4 EVALUATION

a. Availability. No design or construction data were available. Reports concerning the failure of the dam were available and are presented in Appendix B. Survey information was provided by Booker Associates, Inc. and is presented in Plates 3 through 6.

b. Adequacy. The field surveys and visual inspections presented herein are considered adequate to support the conclusions of this report. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and the lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Validity. Not applicable because no design data were available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The dam was inspected by a civil engineer and an engineering geologist from International Engineering Company, Inc. on 28 March 1979. Mr. L. M. Yarberry, a representative of Anschutz Uranium Corporation, met with the inspection team on 28 March 1979. The impoundment behind Main Tailings Dam retains lead tailings, but tailings are no longer conveyed to the pond. The tailings consist of loose, saturated fine sand. Photographs taken during the inspection are included at the end of this report. The field locations of the photographs are shown in Plate 7.

b. Project Geology. Bedrock in the area consists of dolomite of Upper Cambrian age (Geologic Map of Missouri, Missouri Geological Survey, Scale 1:500,000 1979). Some isolated outcrops of Precambrian igneous rocks also occur. Soil cover consists of reddish brown gravelly sandy clay. The thickness of the soil at the left abutment is estimated to be less than about 5 feet. A sand tailings pile is located at the right abutment (see Plates 3 and 7).

c. Dam. The plan of the dam is shown in Plate 3. The profiles and cross-sections of the dam and spillway are shown in Plates 4A, 4B, 5 and 6.

The downstream slope of the main dam is heavily vegetated with trees and brush. There is no vegetation on the secondary dam or on the tailings surface.

There are four large erosion gullies up to 6 feet deep on the downstream face of the main dam. These gullies are located as indicated on Plate 3. Numerous smaller erosion gullies and rills have formed on the main dam and on both faces of the secondary dam. The rills on the secondary dam are up to 6 inches deep. Several cracks were observed on both the upstream and downstream edges of the crest of the secondary dam (see Photo 13). These cracks parallel the alignment of the dam and could be caused by tension. No vertical displacement was observed and the cracks are less than 1/16-inch wide. An old slide that is heavily overgrown was observed on the downstream face of the main dam (see Photo 14). The scarp was apparent and is an overly steep part of the slope. The slide is about 50 feet wide.

Wave erosion has occurred on the upstream face of the secondary dam where the 300-foot plug was constructed to repair the 1977 failure. Water was ponded upstream of the plug, but the depth could not be measured. The upstream slope adjacent to the pond is approximately 1(H) to 1(V), which is steep.

Active piping was visible in the right section of the secondary dam (see Photo 12). The loose, saturated, fine tailings form the foundation of the secondary dam, and these tailings were observed to be actively piping at the time of the inspection. Holes or pipes a few inches in diameter were noted.

A large seepage area was observed downstream of the main dam. The flow could be seen, but it was small. The seepage water has an orange-red film floating on the surface, but the flow is clear beneath this film. Seepage was also observed downstream of the dam at the right end (see Photo 11). The clay soil was very soft in the upper 2 feet of the seepage area, which is near the 48-inch concrete outlet pipe. The quantity of flow was small, but the area affected by the seepage is extensive.

The difference in elevation between the low point in the dam crest and the spillway crest is 2.7 feet. There is no slope protection except for natural vegetation on the downstream face of the main dam.

d. Appurtenant Structures. The spillway is an open channel that has been cut into orange-brown sandy, gravelly clay at the left abutment. The spillway and embankment could be eroded during high discharge. Such discharge could also erode the toe of the main dam. The channel leads into a natural drainage that is perpendicular to the spillway channel. The natural drainage would conduct discharge to the vicinity of the toe of the main dam.

The 48-inch diameter concrete outlet is made up of 4-foot long bell-and-spigot sections. The last section at the downstream end was not grouted and, it is suspected that sections of the entire outlet have not been grouted. The outlet is 850 feet long and is located near the right abutment. The intake structure is an 85-inch by 96-inch concrete box that is connected to the 48-inch pipe. The concrete walls of the box are 8 inches thick. No apparent concrete deterioration was observed. There are two stop-logs in place; these are 1-1/2-inch by 12 inches by 72 inches and are located at the tailings level. The outlet pipe at the downstream end was partially filled with sand at the time of the inspection. The surface of the sand was about 29 inches below the crown at the time of the inspection.

An 8-inch diameter steel pipe is located at the center of the dam in an erosion gully. The pipe is rusted and corroded. The inlet could not be found, and it may be buried. Flow observed through the steel pipe was approximately 2 to 5 gpm. The pipe discharges onto the floodplain downstream of the dam.

The spillway channel from the Upstream Dam (I.D. No. 31080) acts as diversion ditch to the south of the impoundment. The channel connects three small ponds, which are located in small valleys. The channel is U-shaped and varies in depth from 8 to 10 feet.

e. Reservoir Area. The tailings pond consists of saturated, loose, fine sands that are subject to liquefaction. No vegetation is growing on the tailings surface. No evidence of landslides was observed along the shoreline of the tailings area. Erosion along most of the natural shoreline is minor where the shore is wooded.

Erosion is visible in the sand tailings pile that is located just northeast of this pond. Tailings from this area are being washed into the impoundment. Continued deposition of old tailings due to erosion would decrease the storage capacity of the main impoundment area. Based on the size of the erosion gullies in the adjacent tailings pile, the amount of tailings that has been washed into the reservoir area appears to be considerable.

The Upstream Dam (I.D. 31080) limits the upstream end of the tailings pond area. Backwater flooding could reach the downstream face of the upper dam and could possibly cause erosion of the dam face. No other structures would be affected by backwater flooding.

f. Downstream Channels. The Main Tailings Dam was constructed on Toler Creek. Downstream of the dam, the drainage is braided across a plain with sand tailings sediment from the 1977 failure of the tailings dam. Toler Creek flows through residential areas in Cobalt Village and Fredericktown for 1.8 miles before it enters Saline Creek. Saline Creek flows into the Little St. Francis River about 0.5-mile northwest of Fredericktown.

3.2 EVALUATION

The Main Tailings Dam is in poor condition due to serious deficiencies in its stability. The secondary dam embankment was constructed on saturated, loose, fine sands that are piping. This indicates that the foundation of the secondary dam is being weakened by undermining. The dam could become unstable if a sufficient depth of water is impounded. Also, the potential for liquefaction of the sand tailings exists. The deep erosion gullies that were observed on the downstream face of the main dam and the erosion that is caused by wave action on the upstream face of the secondary dam pose hazards to the stability of the structure. The seepage and soft soil conditions at the downstream toe of the main dam could adversely affect embankment stability. The trees growing on the main dam could cause potential seepage problems.

The spillway channel and adjacent embankment would be subject to erosion during heavy flood discharges. The spillway channel does not extend a sufficient distance downstream of the dam. Flood discharge could erode the soils downstream of the dam and/or the embankment. Also, flood discharge from the principal spillway of the Upstream Dam could erode the embankment.

The 8-inch diameter steel pipe is corroding and could collapse; failure of the pipe would threaten embankment stability. Also, the wood stoplogs in the intake structure could deteriorate and allow sand tailings to be washed into the outlet pipe. Deposition of sand was observed at the outlet end of the concrete pipe.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

No regulating procedures are known to exist for this dam. Surface water runoff would pass through an uncontrolled spillway channel at the left abutment and through the outlet structure.

4.2 MAINTENANCE OF DAM

There is no available information pertaining to maintenance of the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

There are no active operating facilities at this dam. Not applicable.

4.4 DESCRIPTION OF WARNING SYSTEM IN EFFECT

Information available to the inspection team indicates that there is no warning system for this dam.

4.5 EVALUATION

The behavior of the dam should be monitored periodically to observe any indications of instability, such as cracks in the dam, sloughing, sudden settlement, erosion of the dam or spillway, or an increase in the volume or turbidity of seepage water. A maintenance program should be initiated for the dam, spillway and outlet structure.

SECTION 5 - HYDRAULIC AND HYDROLOGIC ANALYSES

5.1 EVALUATION OF FEATURES

a. Design Data. The significant dimensions of the dam, spillway, concrete outlet pipe and the intake structure are presented in Section 1 - Project Information, and in the field survey drawings, Plates 3 through 6. Hydrologic and hydraulic design information are not available.

For this evaluation, the watershed drainage area, stream lengths, and reservoir areas were obtained from a 1977 AFC unedited advance print of Fredericktown SE, Mo., 1:24,000 scale Quadrangle. The soil group for this watershed is classified as Goss Cherty Silt Loam, equivalent to a hydrologic soil group B classification, which has a moderate rate of water transmission.

The total drainage area of the Main Tailings Dam, I.D. No. 31082, is 459 acres (0.717 square mile). The watershed and drainage boundary are shown on Plate 2. The Upstream Dam, I.D. No. 31080, is located approximately 2000 feet upstream of the Main Tailings Dam. The watershed of the Main Tailings Dam was subdivided into the following three separate subareas (see Plate 2):

Subarea	Incremental Drainage Area (Acres)
1. Watershed above Upstream Dam	232
2. Local Drainage Area Intercepted by the Upstream Dam Principal Spillway Channel	34
3. Incremental Area between the Upstream Dam and the Main Tailings Dam	193

Land use and vegetation patterns in the watershed were determined from field observations and aerial photographs. The type of land cover and land use were used to estimate runoff curve numbers (CN) for the antecedent moisture conditions (AMC), which in turn, determine the amount of infiltration, retention losses and net runoff.

The data and assumptions used in the hydrologic and hydraulic analyses for each subarea are individually discussed below. Basin parameters such as lag time, unit hydrograph, probable maximum precipitation, losses and net runoff for each subarea are presented in Appendix A.

Subarea 1 - Watershed above Upstream Dam

This subarea refers to the drainage area above the Upstream Dam, I.D. No. 31080. The watershed was divided into the following types of land use and vegetal cover:

Type of Cover	Approximate Percent of Cover
Woodlands	78
Scattered Woodlands	12
Reservoir	10

The estimated runoff curve numbers (CN) weighted according to the above land cover distribution are CN 50 for the antecedent moisture condition (AMC) II condition, and CN 70 for the AMC III condition.

Two spillways are provided for the Upstream Dam: a principal spillway and an emergency spillway. The survey information pertaining to these two spillways is presented in a report entitled "Phase I Inspection Report, National Dam Safety Program, Upstream Dam, Madison County, Missouri, MO 31080, June 1979." They are individually discussed below:

1. Principal Spillway - The principal spillway is located at the west end of the dam. The spillway channel is about 2700 feet long and terminates downstream of the Main Tailings Dam. The channel also diverts runoff from entering the impoundment behind the Main Tailings Dam. It prevents runoff from 34 acres of land located at higher elevations from flowing into the incremental drainage area between the Upstream Dam and the Main Tailings Dam. Detailed hydraulic analysis of the flow conditions along the entire length of the channel is beyond the scope of this study.

   The spillway crest is at about El. 856.0. Two methods were used to derive the spillway discharge rating curve:

   - Critical flows at different critical flow depths were computed using the critical flow formula.

   - Manning's equation for uniform flow, using the slope of the beginning reach of the channel as the average slope (S = 0.0097), and a Manning's "n" of 0.03.

   The discharge capacities computed by both methods are almost identical.

2. Emergency Spillway - The emergency spillway is located at the east end of the embankment. The spillway crest is at El. 860.0, which is 4 feet higher than the principal spillway crest elevation. Two methods were used to derive the emergency spillway rating curve:

- Critical flows at different flow depths using the critical flow formula for a trapezoidal section.

- Weir flow formula using a discharge coefficient of 2.7.

The results computed by the weir formula were considered more representative of the flow conditions at the entrance section (crest) of the emergency spillway.

Computations of flow over the dam crest were made with the weir flow formula assuming a weir discharge coefficient of 3.0.

The discharge rating curves for flow in the principal and emergency spillways and over the dam crest were combined as one composite discharge rating curve. Data for this combined rating curve are in Appendix A, under the input data listing, as Y4 and Y5 cards for the Upstream Dam (Subarea 1), and are also in the computer printouts.

Subarea 2 - Local Drainage Area Intercepted by the Upstream Dam Principal Spillway Channel

This subarea is located on the southwestern side of the watershed. The principal spillway channel of the Upstream Dam separates this subarea from the incremental drainage area between the Upstream Dam and the Main Tailings Dam (Subarea 3). There are three small ponds located along the principal spillway channel. These three ponds have limited storage capacity and serve mainly as detention ponds. This subarea is covered by scattered trees. The estimated runoff curve numbers for Subarea 2 are AMC II, CN 53 and AMC III, CN 74.

Subarea 3 - Incremental Area between the Upstream Dam and the Main Tailings Dam

This subarea is the drainage area between the Upstream Dam and the Main Tailings Dam, excluding the 34 acres of Subarea 2. Land use and type of land cover within this area were estimated as follows:

Type of Cover	Approximate Percent of Cover
Woodlands	53
Tailings (Unsaturated)	17
Tailings (Saturated)	30

The estimated runoff curve numbers are AMC II, CN 61, and AMC III, CN 78.

An open channel spillway is located at the left abutment and a 48-inch diameter concrete outlet pipe connected to a drop intlet structure is located near the right abutment. Computations of the discharge capacities for the spillway and concrete outlet are discussed below:

1. Spillway - Three cross-sections of the spillway channel for the Main Tailings Dam were surveyed (see Plates 4B and 6). The section located 7 feet upstream of the centerline of the dam was used as the representative cross-section because it has the smallest cross-sectional area. Two methods were used to derive the spillway rating curve:

   - Critical flows at different critical flow depths were computed using the critical flow formula.

   - Manning's equation for uniform flow, using the slope of the beginning channel reach as the average slope (S = 0.0148), and a Manning's "n" of 0.03.

   The discharge capacities computed by both methods are similar.

2. Drop Inlet with a 48-inch Diameter Concrete Pipe - The pipe is approximately 850 feet long and it passes underneath the dam. The pipe inverts at the inlet and outlet ends are at El. 819.53 and El. 817.58, respectively. Details of the drop inlet (intake structure) are shown on Plate 3.

   Three possible flow conditions can exist, depending on the head over the inlet. At very low heads, the drop inlet sill acts as a weir and the flow is weir controlled. As the reservoir water surface rises, interaction occurs between water flowing in from both sides of the inlet and the inlet acts as an orifice. At still higher water surface elevations, the outlet pipe eventually flows full and pipe flow controls. The discharge rating curve for the 48-inch diameter concrete outlet pipe was computed according to the following assumed conditions:

   - Weir flow condition when the reservoir water surface is below El. 832.5. A weir discharge coefficient of 3.0 and an average weir crest of El. 830.6 were used.

   - Orifice flow condition when the reservoir water surface is between El. 832.5 and El. 836.0. An orifice discharge coefficient of 0.6 was assumed.

   - Pipe flow condition when the reservoir water surface is above El. 836.0. The head losses for the pipe flow include entrance loss, friction loss, and other miscellaneous losses. Pipe roughness was assumed to be equivalent to a Manning's "n" of 0.015.

Detailed hydraulic analysis of the possible flow conditions within the pipe and whether the pipe acts as a hydraulically long or short-conduit is beyond the scope of the present study.

Flow over the dam crest was computed by the weir formula with C = 3.0. Data for the reservoir water surface elevation versus discharge relationship are shown in Appendix A as Y4 and Y5 cards in the input data listing and are also in the computer printouts.

b. Experience Data. Rainfall, streamflow and other flood data for the watershed are not available. The Main Tailings Dam failed in March 1977 (see Section 2 and Appendix B). The principal spillway channel for the Upstream Dam was enlarged in April 1979.

c. Visual Observations. Specific information on the visual observations is presented in Section 3 - Visual Inspection.

d. Overtopping Potential. The analyses of flow regime, flood magnitudes, flood volumes and the overtopping potential of the Main Tailings Dam were divided into the following successive steps:

- Compute and route floods for Subarea 1, the Upstream Dam watershed and reservoir.
- Separate the routed outflows from the Upstream Dam into outflow hydrographs from the principal spillway and from the emergency spillway.
- Compute floods for Subarea 2, the drainage area intercepted by the principal spillway channel.
- Combine the outflows from the principal spillway with floods from Subarea 2. If the combined flows are less than the spillway channel capacity (about 1000 cfs), then the combined flows are assumed to be completely diverted away by the channel and there would be no flood inflow into Subarea 3 and the tailings impoundment from Subarea 2. However, if a given flood overtops the Upstream Dam, then all outflow (from both principal and emergency spillways and dam crest overflow) from the Upstream Dam plus all flow from Subarea 2 are considered as inflow into the tailings impoundment behind the Main Tailings Dam.
- Compute floods from Subarea 3, the incremental drainage area bounded by the Upstream Dam, the principal spillway channel, and the Main Tailings Dam.
- Combine the computed floods from Subarea 3 with the inflow from Subareas 1 and 2 under the different conditions and combinations as mentioned above. This yields the total inflow into the tailings impoundment.

- Route the total inflow through the spillway and the 48-inch-diameter concrete pipe to determine the overtopping potential of the Main Tailings Dam.

The 100-year flood, probable maximum flood (PMF), and floods expressed as percentages of the PMF were individually computed for each subarea, following the steps described above. The PMF is defined as the flood event that would result from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible at a particular location or region.

The following results were obtained from separate hydrologic and hydraulic analyses of the Upstream Dam (for details, see "Phase I Inspection Report, National Dam Safety Program, Upstream Dam, Madison County, Missouri, MO 31080, June 1979"):

- The principal spillway is able to pass the 100-year flood. The maximum reservoir water surface elevation for the 100-year flood is El. 857.4, 2.6 feet below the crest elevation of the emergency spillway (El. 860).

- It was estimated that the principal spillway can pass about 25 percent of the PMF (peak outflow, 205 cfs, velocity of 7.2 feet per second and flow depth of about 3.2 feet) before the reservoir water surface elevation reaches the crest elevation of the emergency spillway.

- It was calculated that the dam would be overtopped during PMF conditions. However, it was computed that both the principal and emergency spillways combined can pass about 67 percent of the PMF without overtopping the lowest point of the embankment. At 67 percent of the PMF, the discharge of the principal and the emergency spillways is 680 cfs and 140 cfs, respectively, with a combined discharge of 820 cfs. The flow depth in the principal spillway is 6.2 feet, with a flow velocity of 10.4 feet per second. The flow depth in the emergency spillway is 3.4 feet, with a flow velocity of about 5.0 feet per second.

- If potential erosion of the spillways and embankment is considered, the principal spillway can pass an estimated 12 percent of the PMF without significant erosion if a maximum permissible flow velocity of 5 feet per second is allowed in the spillway control section. At 12 percent of the PMF, the maximum reservoir water surface elevation would not reach the emergency spillway crest elevation and the outflow would be discharged entirely through the principal spillway. Peak outflow for 12 percent of the PMF is about 60 cfs, at a flow depth of about 2.0 feet at the entrance, and a velocity of 5 feet per second.

Because of the different outflow conditions that can exist at the Upstream Dam, several combinations of inflow to the tailings impoundment can be made.

In this analysis, the inflow conditions to the tailings impoundment for the overtopping analysis are simplified into three likely cases, with the following assumptions:

Case 1 - Inflow from Subarea 3

The only inflow into the tailings impoundment is from Subarea 3. In this case, runoff from the upstream Subarea 1 is intercepted by the Upstream Dam. The principal spillway of the Upstream Dam diverts all flow from Subarea 1 to below the Main Tailings Dam and the spillway also intercepts all flow from Subarea 2. The reservoir elevation of the Upstream Dam does not reach the emergency spillway crest in this case and no outflow through the emergency spillway into Subarea 3 occurs.

Case 1 is applicable to the 100-year flood analysis and to the 25 percent of the PMF analysis.

Case 2 - Inflow from Subarea 3 plus Routed Outflow from the Upstream Dam Emergency Spillway

This condition exists when the upstream reservoir elevation is above the emergency spillway crest but before the Upstream Dam is overtopped. Inflow to the tailings impoundment consists of Subarea 3 runoff, plus the routed outflow from the emergency spillway. In this case, the majority of the Subarea 1 runoff from the upstream reservoir is diverted away from the tailings impoundment via the Upstream Dam principal spillway and the runoff from Subarea 2 is completely intercepted by the principal spillway channel.

The analyses of 55 percent of the PMF and 60 percent of the PMF apply to the Case 2 inflow condition.

Case 3 - Runoff from the Entire Watershed above the Main Tailings Dam

This is the most severe hydrologic condition; all flow from Subareas 1, 2 and 3 drain into the tailings impoundment. For Subarea 3, flood runoff would drain into the tailings impoundment. For Subarea 1, it was assumed that once the Upstream Dam was overtopped, all outflow would be directed into Subarea 3 and into the tailings impoundment. For Subarea 2 runoff, it was assumed that the principal spillway channel would not be able to intercept the flood flow; all flow would be directed into Subarea 3 and the tailings impoundment. To simplify hydrologic computations, Subareas 2 and 3 were combined as one area for the estimation of surface runoff. No retardation in travel time that might be caused by the intercepting spillway channel was assumed.

The analyses of 68 percent of the PMF, 75 percent of the PMF and the PMF apply to the Case 3 inflow condition.

The above-mentioned three cases of inflow conditions involve simplified assumptions. To fully analyze the manner in which the Upstream Dam would fail requires detailed breaching analyses. In this study, therefore, the routed outflow hydrographs from the subareas do not reflect the sudden outburst of flood waters due to a breaching of the dam. Similar assumptions were also made for the Upstream Dam principal spillway channel in that Subarea 2 runoff is either diverted away by the channel or all runoff is directed into Subarea 3 and the tailings impoundment.

The computed floods were routed through the reservoir and spillway using the Modified Puls Method of flood routing. For all cases of spillway flood routing, the starting water surface elevation was set at the spillway crest at El. 833.0.

Results of the routing studies indicate that the spillway is able to pass the 100-year flood. Routing studies of floods expressed as percentages of the PMF indicate that the spillway can pass about 59 percent of the PMF without overtopping the lowest point of the embankment. However, at 59 percent of the PMF, the peak spillway routed outflow is about 330 cfs, with a flow depth of 2.0 feet and a flow velocity of about 6.5 feet per second. High velocities and discharges such as those at 59 percent PMF peak outflow could cause significant erosion of the spillway channel and the adjacent embankment.

A major consideration in evaluating the safety of the dam is assessing the potential for overtopping and the subsequent failure of the embankment as a result of significant erosion. Since the spillway appears to be composed of erodible materials, high velocity discharges through the spillway could lead to significant erosion of the spillway and adjacent embankment even if the dam is not overtopped. Based on the Corps of Engineers Manual EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", the maximum permissible velocity of the materials found in the spillway was estimated at about 5 feet per second. Using this as a criterion, it was estimated that the spillway can pass about 38 percent of the PMF without significant erosion. The 38 percent PMF peak routed outflow from the spillway was computed at about 85 cfs, at a flow depth of about 0.9 foot. The computed outflow through the outlet pipe is 116 cfs. Thus, for determining the erosion potential of the embankment near the spillway entrance, flows above 85 cfs and flow depths in the spillway greater than 0.9-foot could produce the effects of significant erosion and subsequent embankment failure.

Results of the overtopping analyses are reported in Appendix A and are summarized in the following table.

Flood	Peak Inflow (cfs)	Combined Peak Outflow(1) (cfs)	Max Res WS Elev(2) ft	Spillway Flow Depth (ft)	Spillway Flow Velocity (ft/sec)	Duration Spillway Vel. over 5 ft/sec (hr)
25% PMF	807	121	833.5	0.3	3.2	0
55% PMF	1779	432	835.5	1.9*	6.3*	5.1
60% PMF	1942	529	835.8**	2.1**	6.5**	5.5
68% PMF	2933	2198	836.7**	2.8**	7.3**	11.3
75% PMF	3260	2661	836.8**	2.9**	7.4**	11.7
PMF	4402	3974	837.1**	3.1**	8.2**	13.3

* These flow depths and velocities are considered to produce the effects of significant erosion.

** Dam overtopped (Minimum Dam Crest, El. 835.7 feet).

Notes:

(1) Outflow through spillway and 48-inch diameter outlet pipe.

(2) Reservoir water surface elevations include the velocity heads corresponding to the velocities computed at the various flow depths for the spillway section.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. The conditions that adversely affect the structural stability of the dam are discussed in Section 3.

b. Design and Construction Data. No design or construction data pertaining to the structural stability of the dam were available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, and lack of this information is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions, including earthquake loads, and made a matter of record.

c. Operating Records. No appurtenant structures requiring operation exist at this dam and no records are known to exist.

d. Post Construction Changes. The dam was breached in the 1950's. The dam was repaired after it failed in 1977. Documentation of the 1977 failure and other information are contained in reports by personnel from the Missouri Geology and Land Survey, Applied Engineering and Urban Geology. Those reports are listed as follows:

Report by T. J. Dean, 30 March 1977
Report by C. J. Stohr, 15 November 1977
Report by J. H. Williams, 14 February 1978

Details concerning the 1977 failure are presented in Section 2.

e. Seismic Stability. The dam is located in Seismic Zone 2, as defined in the Uniform Building Code. There appears to be a high potential for liquefaction of the secondary dam foundation, which consists of loose, saturated fine sand tailings.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. There are several deficiencies that should be corrected. (1) No erosion protection has been provided in the spillway channel. Also, discharge from the spillway and from the principal spillway of the Upstream Dam could erode the soils downstream of the dam and/or the embankment. (2) No erosion protection has been provided on the upstream and downstream faces of the secondary dam. (3) The seepage and soft soil conditions downstream of the main dam and the piping of the secondary dam adversely affect embankment stability. The dam could become unstable if a sufficient depth of water is impounded to accelerate piping. (4) The deep erosion gullies on the face of the main dam adversely affect embankment stability. (5) The 8-inch diameter steel pipe is corroding and could collapse; this would threaten embankment stability. (6) The wood stop-logs in the intake structure could deteriorate, which would result in sand tailings being deposited in the outlet pipe. Sand partially fills the outlet pipe at the downstream end. (7) Tailings from the adjacent tailings pile are being washed into the impoundment causing a loss of storage capacity. (8) Trees on the main dam could cause a potential seepage hazard. (9) Seepage and stability analyses were not available, and they should be performed and made a matter of record. (10) The combined discharge capacity of the spillway and outlet was computed to be inadequate to pass 50 percent of the Probable Maximum Flood (PMF) without overtopping the dam and without significant erosion of the spillway and embankment. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that is reasonably possible in the region. The "Recommended Guidelines for Safety Inspection of Dams" specifies that the spillway design flood for this dam should be 50 to 100 percent of the PMF. However, the spillway design flood adopted for this dam is 100 percent of the PMF because the consequences of failure are serious. This dam is about 1/4-mile from a residential area of Fredericktown, Missouri.

b. Adequacy of Information. No detailed design or construction data were available. Seepage and stability analyses comparable to the requirements of "Recommended Guidelines for Safety Inspection of Dams" were not available, and this lack of data is considered a deficiency.

Results of the hydrologic studies could be changed if larger scale topographic maps with smaller contour intervals were used. The only available topographic maps are the 1:62,500 scale USGS quadrangle and the 1:24,000 scale USGS quadrangle (AFC unedited advance print) with contour intervals of 20 feet. All measurements made on the maps, such as drainage area, stream lengths, river slopes, and area-capacity data, are insufficient in details; but the maps suffice for the Phase I inspection. The use of the USGS quadrangles for the hydrologic studies results in an approximate evaluation of the spillway flood discharge capacity.

c. Urgency. The Phase I inspection indicated serious deficiencies in the condition of the dam and spillway. Seepage and stability analyses, remedial measures to the spillway, and control of piping through the dam should be given priority and immediate attention.

d. Necessity for Phase II. No Phase II investigation is recommended; however, additional investigations are recommended as outlined in Section 7.2.h.

7.2 REMEDIAL MEASURES

The following remedial measures are recommended:

a. The erosion gullies in the main and secondary dams should be repaired. Erosion protection should be provided on the upstream and downstream faces of the dam.

b. Adequate erosion protection should be provided in the spillway channel. Erosion protection should be adequate to withstand the peak discharge velocity resulting from the PMF.

c. The spillway should be extended a sufficient distance downstream of the dam to prevent discharges from eroding the embankment and/or the soils immediately downstream of the embankment toe.

d. The channel at the downstream end of the 48-inch diameter outlet pipe should be cleared of sand.

e. The 8-inch diameter pipe should be removed or completely plugged with concrete to prevent it from collapsing and threatening embankment stability.

f. Measures to reduce erosion of the tailings pile located north of the impoundment should be initiated to limit sedimentation in the reservoir and consequent loss of storage capacity.

g. The combined spillway and outlet capacity was calculated to be adequate to pass 38 percent of the PMF without significant erosion of the spillway and embankment and without overtopping the dam. To comply with the guidelines for a dam of this size and hazard potential, the spillway should be enlarged and/or the freeboard increased so that the PMF can be passed without overtopping the dam crest and without significant erosion of the spillway or embankment.

h. Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of tailings dams. Included in these analyses, computations should be performed with the water surface in the impoundment set at the top of the dam. The necessary data for these analyses would be obtained from additional investigations. The investigations should consist of sub-surface exploration and soil sampling and a laboratory testing program to obtain the necessary engineering parameters of the dam and foundation materials. These parameters should be used in an engineering study to evaluate the stability of the dam. Concurrent with the exploratory work, groundwater monitoring wells should be installed in the drill holes to obtain water level data that would be used in the stability studies. Remedial measures to the dam should be based on the results of the stability studies and should be done under the direction of a professional engineer experienced in tailings dam design and construction.

i. Specific remedial work should be addressed to controlling active piping of tailings through the dam. This remedial work should be based on appropriate analyses of this condition and should be performed under the direction of an engineer experienced in the design and construction of tailings dams.

j. An engineer experienced in the design and construction of tailings dams should direct the removal of trees from the dam.

k. The wood stop-logs of the intake should be inspected periodically for signs of deterioration, and they should be replaced as necessary. Alternatively, the stop-logs could be removed and a concrete sill constructed in their place.

l. An inspection and maintenance program should be initiated. Periodic inspections should be made by qualified personnel to observe the performance of the dam, spillway and outlet. Observations should include indications of instability, such as cracks in the embankment, sloughing, erosion, sudden settlement or an increase in the volume or turbidity of the seepage areas. Records should be kept of these inspections and of any corrective maintenance made to the dam, spillway, outlet pipe and intake structure.

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

The hydrologic and hydraulic analyses were accomplished by using the computer program "Flood Hydrograph Package, HEC-1, Dam Safety Investigations Version, July 1978". This program was developed by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The criteria and methodology used are briefly discussed below:

- Probable Maximum Precipitation (PMP) - The 24-hour PMP was obtained from Hydrometeorological Report No. 33. The 6-hour and the 1-hour depth-duration distributions followed Corps of Engineers EM 1110-2-1411 criteria.

- 100-year and/or 10-year storms - The 24-hour storm amounts and distributions were supplied by Corps of Engineers, St. Louis District, Missouri.

- Unit Hydrograph - The Soil Conservation Service (SCS) curvelinear unit nydrograph method was used. Basin lag time was computed by using the SCS Curve Number Method and equation.

- Hydrologic Soil Group, Antecedent Moisture Condition (AMC) and Curve Number (CN) - The predominant hydrologic soil group for the watershed was obtained from an agricultural soil classification map prepared by the University of Missouri Agricultural Experiment Station. For the PMF and floods expressed as a percent of PMF, AMC III conditions were used. For the 100-year and/or 10-year floods, AMC II conditions were assumed. Watershed CN was estimated from field observations and from aerial photos.

- Reservoir Area-Capacity - Areas were measured from U.S.G.S. topographic maps. Reservoir elevations and corresponding surface areas were input in the computer program, which determined the reservoir capacities by the Conic Method.

- Reservoir and Spillway Flood Routing - The Modified Puls Method was used for all flood routing through spillway and dam overtopping analyses.

The following pages present the input data listing, the computer program version and its last modification date, together with pertinent computer printouts of results. Definitions of all input and output variable names are presented in the computer program "Users Manual", September 1978, and are not explained herein.

```
A1        ANCHUTZ TAILING DAM ID NO 31082
A2        HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3        RATIOS OF PMF ROUTED THROUGH RESERVOIR
B    288               5
B1     5
J      1       3       1
J1   .68     .75     1.0
K      0 INFLOW                        1       1       1
K1 INFLOW FROM DRAINAGE AREA ABOVE DAM ID # 31080
M      1       2   .3625                       1                       1
P      0    26.5     102     120     130
T                                                     -1     -70              .1
W2                    .6
X    -10     -.1     2.5
K      1   LAKE                        1       1       1
K1 ROUTING OF PMF THROUGH RESERVOIR OF DAM ID # 31080
Y                                1       1
Y1     1                                          -856.0      -1
Y4 856.0   857.1   858.4   859.7   861.0   863.0   863.9   864.5   865.0   866.5
Y5     0       9      63     161     291     635     840    1106    1579    5713
$A     0       5    12.5      19      23    28.4    38.7      59
$E   830     840     850     856     860   863.8     870     880
$$ 856.0
$D 863.8
K      0   L FLO                       1       1       1
K1 PMF INFLOW FROM LOCAL DRAINAGE AREA
M      1       2  0.3547                       1                       1
P      0    26.5     102     120     130
T                                                     -1     -78            0.26
W2                  0.24
X    -10     -.1     2.5
```

```
K        2   COMBD                                  1       1       1
K1 COMBINED PMF FROM LOCAL INFLOW & OUTFLOW FROM UPPER RESERVOIR
K        1   LAKE2                                  2       1       1
K1 ROUTING OF COMBINED PMF THROUGH RESERVOIR
Y                                           1       1
Y1       1                                                      -833.      -1
Y4  830.6   831.0   831.5   832.0   832.5   833.0   833.5   834.0   834.5   835.0
Y4  835.7   836.0   836.5   837.0   837.5   838.0   839.0   840.0   841.0
Y5    0.0      8.     28.     53.     83.     94.    120.    165.    225.    310.
Y5   470.    730.   1650.   3520.   6320.   9320.  16530.  26030.  36730.
$A     0.    16.4    38.0    40.0    42.0    43.5    46.4    48.7    53.3    58.0
$E   800.    820.    833.    834.    835.   835.7    837.    838.    840.    842.
$$  833.0
$D  835.7
K       99
A
A
A
A
A
```

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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE* 79/07/19.
     TIME* 15.46.09.


                    ANCHUTZ TAILING DAM ID NO 31082
                    HEC-1  PHASE I  DAM SAFETY INVESTIGATIONS
                    RATIOS OF PMF ROUTED THROUGH RESERVOIR

                                     JOB SPECIFICATION
          NQ     NHR    NMIN    IDAY     IHR    IMIN  METRC    IPLT    IPRT   NSTAN
         288       0       5       0       0       0      0       0       0       0
                                 JOPER     NWT   LROPT  TRACE
                                     5       0       0      0

                          MULTI-PLAN ANALYSES TO BE PERFORMED
                            NPLAN= 1 NRTIO= 3 LRTIO= 1
         RTIOS=     .68    .75   1.00


   **********        **********        **********        **********        **********

                             SUB-AREA RUNOFF COMPUTATION

        INFLOW FROM DRAINAGE AREA ABOVE DAM ID # 31080

                   ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                  INFLOW       0       0       0       1       1       1       0       0

                                     HYDROGRAPH DATA
        IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
            1      2     .36    0.00     .36    1.00   0.000       0       1       0

                                       PRECIP DATA
                    SPFE     PMS      R6     R12     R24     R48     R72     R96
                    0.00   26.50  102.00  120.00  130.00    0.00    0.00    0.00

                                        LOSS DATA
     LROPT  STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
         0   0.00   0.00   1.00   0.00   0.00   1.00  -1.00 -70.00   0.00    .10

        CURVE NO =  -70.00  WETNESS =   -1.00  EFFECT CN =   70.00

                                  UNIT HYDROGRAPH DATA
                               TC=  0.00    LAG=    .60

                                      RECESSION DATA
                         STRTQ=  -10.00    QRCSN=   -.10    RTIOR= 2.50

      UNIT HYDROGRAPH 38 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=    .60  VOL= 1.00
       14.       42.       81.      138.      202.      248.      270.      272.      254.      235.
      205.      166.      129.      103.       84.       69.       56.       45.       36.       29.
```

24. 19. 15. 13. 10. 8. 7. 5. 4. 4.
3. 2. 2. 2. 1. 1. 1. 0.

0 END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	3.	1.01	12.05	145	.23	.18	.04	147.
1.01	.10	2	.01	.00	.01	3.	1.01	12.10	146	.23	.18	.04	153.
1.01	.15	3	.01	.00	.01	3.	1.01	12.15	147	.23	.19	.04	164.
1.01	.20	4	.01	.00	.01	3.	1.01	12.20	148	.23	.19	.04	183.
1.01	.25	5	.01	.00	.01	3.	1.01	12.25	149	.23	.19	.04	210.
1.01	.30	6	.01	.00	.01	3.	1.01	12.30	150	.23	.19	.03	243.
1.01	.35	7	.01	.00	.01	3.	1.01	12.35	151	.23	.19	.03	280.
1.01	.40	8	.01	.00	.01	4.	1.01	12.40	152	.23	.19	.03	317.
1.01	.45	9	.01	.00	.01	4.	1.01	12.45	153	.23	.20	.03	353.
1.01	.50	10	.01	.00	.01	4.	1.01	12.50	154	.23	.20	.03	386.
1.01	.55	11	.01	.00	.01	4.	1.01	12.55	155	.23	.20	.03	416.
1.01	1.00	12	.01	.00	.01	4.	1.01	13.00	156	.23	.20	.03	441.
1.01	1.05	13	.01	.00	.01	4.	1.01	13.05	157	.27	.24	.03	461.
1.01	1.10	14	.01	.00	.01	4.	1.01	13.10	158	.27	.24	.03	480.
1.01	1.15	15	.01	.00	.01	5.	1.01	13.15	159	.27	.24	.03	497.
1.01	1.20	16	.01	.00	.01	5.	1.01	13.20	160	.27	.24	.03	515.
1.01	1.25	17	.01	.00	.01	5.	1.01	13.25	161	.27	.24	.03	533.
1.01	1.30	18	.01	.00	.01	5.	1.01	13.30	162	.27	.25	.02	553.
1.01	1.35	19	.01	.00	.01	5.	1.01	13.35	163	.27	.25	.02	571.
1.01	1.40	20	.01	.00	.01	5.	1.01	13.40	164	.27	.25	.02	589.
1.01	1.45	21	.01	.00	.01	5.	1.01	13.45	165	.27	.25	.02	606.
1.01	1.50	22	.01	.00	.01	4.	1.01	13.50	166	.27	.25	.02	621.
1.01	1.55	23	.01	.00	.01	4.	1.01	13.55	167	.27	.25	.02	634.
1.01	2.00	24	.01	.00	.01	4.	1.01	14.00	168	.27	.25	.02	646.
1.01	2.05	25	.01	.00	.01	4.	1.01	14.05	169	.34	.31	.02	656.
1.01	2.10	26	.01	.00	.01	4.	1.01	14.10	170	.34	.32	.02	667.
1.01	2.15	27	.01	.00	.01	4.	1.01	14.15	171	.34	.32	.02	679.
1.01	2.20	28	.01	.00	.01	4.	1.01	14.20	172	.34	.32	.02	694.
1.01	2.25	29	.01	.00	.01	4.	1.01	14.25	173	.34	.32	.02	712.
1.01	2.30	30	.01	.00	.01	4.	1.01	14.30	174	.34	.32	.02	732.
1.01	2.35	31	.01	.00	.01	4.	1.01	14.35	175	.34	.32	.02	754.
1.01	2.40	32	.01	.00	.01	4.	1.01	14.40	176	.34	.32	.02	775.
1.01	2.45	33	.01	.00	.01	4.	1.01	14.45	177	.34	.32	.02	795.
1.01	2.50	34	.01	.00	.01	4.	1.01	14.50	178	.34	.32	.02	813.
1.01	2.55	35	.01	.00	.01	4.	1.01	14.55	179	.34	.32	.02	829.
1.01	3.00	36	.01	.00	.01	4.	1.01	15.00	180	.34	.32	.02	842.
1.01	3.05	37	.01	.00	.01	4.	1.01	15.05	181	.21	.20	.01	851.
1.01	3.10	38	.01	.00	.01	4.	1.01	15.10	182	.41	.39	.02	858.
1.01	3.15	39	.01	.00	.01	4.	1.01	15.15	183	.41	.39	.02	863.
1.01	3.20	40	.01	.00	.01	4.	1.01	15.20	184	.62	.59	.02	871.
1.01	3.25	41	.01	.00	.01	4.	1.01	15.25	185	.72	.69	.03	888.
1.01	3.30	42	.01	.00	.01	4.	1.01	15.30	186	1.75	1.69	.06	935.
1.01	3.35	43	.01	.00	.01	4.	1.01	15.35	187	2.88	2.80	.08	1046.
1.01	3.40	44	.01	.00	.01	4.	1.01	15.40	188	1.13	1.10	.03	1226.
1.01	3.45	45	.01	.00	.01	4.	1.01	15.45	189	.72	.70	.02	1471.
1.01	3.50	46	.01	.00	.01	4.	1.01	15.50	190	.62	.60	.01	1771.
1.01	3.55	47	.01	.00	.01	4.	1.01	15.55	191	.41	.40	.01	2071.
1.01	4.00	48	.01	.00	.01	4.	1.01	16.00	192	.41	.40	.01	2301.
1.01	4.05	49	.01	.00	.01	4.	1.01	16.05	193	.32	.31	.01	2430.
1.01	4.10	50	.01	.00	.01	4.	1.01	16.10	194	.32	.31	.01	2458.
1.01	4.15	51	.01	.00	.01	4.	1.01	16.15	195	.32	.31	.01	2402.
1.01	4.20	52	.01	.00	.01	4.	1.01	16.20	196	.32	.31	.01	2280.
1.01	4.25	53	.01	.00	.01	4.	1.01	16.25	197	.32	.31	.01	2112.
1.01	4.30	54	.01	.00	.01	4.	1.01	16.30	198	.32	.31	.01	1913.

1.01	4.35	55	.01	.00	.01	4.	1.01	16.35	199	.32	.31	.01	1760.
1.01	4.40	56	.01	.00	.01	4.	1.01	16.40	200	.32	.31	.01	[illegible]
1.01	4.45	57	.01	.00	.01	4.	1.01	16.45	201	.32	.31	.01	1432.
1.01	4.50	58	.01	.00	.01	4.	1.01	16.50	202	.32	.31	.00	1327.
1.01	4.55	59	.01	.00	.01	4.	1.01	16.55	203	.32	.31	.00	1241.
1.01	5.00	60	.01	.00	.01	4.	1.01	17.00	204	.32	.31	.00	[illegible]
1.01	5.05	61	.01	.00	.01	4.	1.01	17.05	205	.25	.24	.00	1112.
1.01	5.10	62	.01	.00	.01	4.	1.01	17.10	206	.25	.24	.00	1063.
1.01	5.15	63	.01	.00	.01	4.	1.01	17.15	207	.25	.24	.00	1020.
1.01	5.20	64	.01	.00	.01	4.	1.01	17.20	208	.25	.24	.00	981.
1.01	5.25	65	.01	.00	.01	4.	1.01	17.25	209	.25	.24	.00	942.
1.01	5.30	66	.01	.00	.01	4.	1.01	17.30	210	.25	.24	.00	907.
1.01	5.35	67	.01	.00	.01	5.	1.01	17.35	211	.25	.24	.00	873.
1.01	5.40	68	.01	.00	.01	5.	1.01	17.40	212	.25	.24	.00	842.
1.01	5.45	69	.01	.00	.01	5.	1.01	17.45	213	.25	.24	.00	815.
1.01	5.50	70	.01	.00	.01	5.	1.01	17.50	214	.25	.24	.00	791.
1.01	5.55	71	.01	.00	.01	5.	1.01	17.55	215	.25	.24	.00	770.
1.01	6.00	72	.01	.00	.01	5.	1.01	18.00	216	.25	.24	.00	754.
1.01	6.05	73	.07	.01	.05	6.	1.01	18.05	217	.02	.02	.00	738.
1.01	6.10	74	.07	.01	.05	6.	1.01	18.10	218	.02	.02	.00	719.
1.01	6.15	75	.07	.02	.05	7.	1.01	18.15	219	.02	.02	.00	692.
1.01	6.20	76	.07	.02	.05	9.	1.01	18.20	220	.02	.02	.00	654.
1.01	6.25	77	.07	.02	.05	12.	1.01	18.25	221	.02	.02	.00	603.
1.01	6.30	78	.07	.02	.05	15.	1.01	18.30	222	.02	.02	.00	543.
1.01	6.35	79	.07	.02	.05	19.	1.01	18.35	223	.02	.02	.00	478.
1.01	6.40	80	.07	.02	.04	23.	1.01	18.40	224	.02	.02	.00	414.
1.01	6.45	81	.07	.02	.04	28.	1.01	18.45	225	.02	.02	.00	353.
1.01	6.50	82	.07	.02	.04	33.	1.01	18.50	226	.02	.02	.00	299.
1.01	6.55	83	.07	.03	.04	37.	1.01	18.55	227	.02	.02	.00	252.
1.01	7.00	84	.07	.03	.04	41.	1.01	19.00	228	.02	.02	.00	[illegible]
1.01	7.05	85	.07	.03	.04	45.	1.01	19.05	229	.02	.02	.00	204.
1.01	7.10	86	.07	.03	.04	49.	1.01	19.10	230	.02	.02	.00	[illegible]
1.01	7.15	87	.07	.03	.04	53.	1.01	19.15	231	.02	.02	.00	173.
1.01	7.20	88	.07	.03	.04	57.	1.01	19.20	232	.02	.02	.00	158.
1.01	7.25	89	.07	.03	.04	60.	1.01	19.25	233	.02	.02	.00	144.
1.01	7.30	90	.07	.03	.03	64.	1.01	19.30	234	.02	.02	.00	132.
1.01	7.35	91	.07	.03	.03	67.	1.01	19.35	235	.02	.02	.00	120.
1.01	7.40	92	.07	.03	.03	70.	1.01	19.40	236	.02	.02	.00	110.
1.01	7.45	93	.07	.03	.03	73.	1.01	19.45	237	.02	.02	.00	[illegible]
1.01	7.50	94	.07	.03	.03	76.	1.01	19.50	238	.02	.02	.00	91.
1.01	7.55	95	.07	.04	.03	78.	1.01	19.55	239	.02	.02	.00	83.
1.01	8.00	96	.07	.04	.03	81.	1.01	20.00	240	.02	.02	.00	76.
1.01	8.05	97	.07	.04	.03	84.	1.01	20.05	241	.02	.02	.00	70.
1.01	8.10	98	.07	.04	.03	86.	1.01	20.10	242	.02	.02	.00	68.
1.01	8.15	99	.07	.04	.03	88.	1.01	20.15	243	.02	.02	.00	67.
1.01	8.20	100	.07	.04	.03	91.	1.01	20.20	244	.02	.02	.00	66.
1.01	8.25	101	.07	.04	.03	93.	1.01	20.25	245	.02	.02	.00	65.
1.01	8.30	102	.07	.04	.03	95.	1.01	20.30	246	.02	.02	.00	64.
1.01	8.35	103	.07	.04	.03	97.	1.01	20.35	247	.02	.02	.00	63.
1.01	8.40	104	.07	.04	.03	99.	1.01	20.40	248	.02	.02	.00	63.
1.01	8.45	105	.07	.04	.02	101.	1.01	20.45	249	.02	.02	.00	62.
1.01	8.50	106	.07	.04	.02	103.	1.01	20.50	250	.02	.02	.00	62.
1.01	8.55	107	.07	.04	.02	105.	1.01	20.55	251	.02	.02	.00	62.
1.01	9.00	108	.07	.04	.02	106.	1.01	21.00	252	.02	.02	.00	61.
1.01	9.05	109	.07	.04	.02	108.	1.01	21.05	253	.02	.02	.00	61.
1.01	9.10	110	.07	.04	.02	110.	1.01	21.10	254	.02	.02	.00	61.
1.01	9.15	111	.07	.04	.02	111.	1.01	21.15	255	.02	.02	.00	61.
1.01	9.20	112	.07	.04	.02	113.	1.01	21.20	256	.02	.02	.00	61.
1.01	9.25	113	.07	.04	.02	114.	1.01	21.25	257	.02	.02	.00	61.
1.01	9.30	114	.07	.05	.02	116.	1.01	21.30	258	.02	.02	.00	61.

1.01	9.35	115	.07	.05	.02	117.	1.01	21.35	259	.02	.02	.00	61.
1.01	9.40	116	.07	.05	.02	118.	1.01	21.40	260	.02	.02	.00	61.
1.01	9.45	117	.07	.05	.02	120.	1.01	21.45	261	.02	.02	.00	61.
1.01	9.50	118	.07	.05	.02	121.	1.01	21.50	262	.02	.02	.00	61.
1.01	9.55	119	.07	.05	.02	122.	1.01	21.55	263	.02	.02	.00	61.
1.01	10.00	120	.07	.05	.02	123.	1.01	22.00	264	.02	.02	.00	61.
1.01	10.05	121	.07	.05	.02	125.	1.01	22.05	265	.02	.02	.00	61.
1.01	10.10	122	.07	.05	.02	126.	1.01	22.10	266	.02	.02	.00	61.
1.01	10.15	123	.07	.05	.02	127.	1.01	22.15	267	.02	.02	.00	61.
1.01	10.20	124	.07	.05	.02	128.	1.01	22.20	268	.02	.02	.00	61.
1.01	10.25	125	.07	.05	.02	129.	1.01	22.25	269	.02	.02	.00	61.
1.01	10.30	126	.07	.05	.02	130.	1.01	22.30	270	.02	.02	.00	61.
1.01	10.35	127	.07	.05	.02	131.	1.01	22.35	271	.02	.02	.00	61.
1.01	10.40	128	.07	.05	.02	132.	1.01	22.40	272	.02	.02	.00	61.
1.01	10.45	129	.07	.05	.02	133.	1.01	22.45	273	.02	.02	.00	61.
1.01	10.50	130	.07	.05	.02	134.	1.01	22.50	274	.02	.02	.00	61.
1.01	10.55	131	.07	.05	.02	135.	1.01	22.55	275	.02	.02	.00	61.
1.01	11.00	132	.07	.05	.02	136.	1.01	23.00	276	.02	.02	.00	61.
1.01	11.05	133	.07	.05	.02	136.	1.01	23.05	277	.02	.02	.00	61.
1.01	11.10	134	.07	.05	.01	137.	1.01	23.10	278	.02	.02	.00	61.
1.01	11.15	135	.07	.05	.01	138.	1.01	23.15	279	.02	.02	.00	61.
1.01	11.20	136	.07	.05	.01	139.	1.01	23.20	280	.02	.02	.00	61.
1.01	11.25	137	.07	.05	.01	140.	1.01	23.25	281	.02	.02	.00	61.
1.01	11.30	138	.07	.05	.01	140.	1.01	23.30	282	.02	.02	.00	61.
1.01	11.35	139	.07	.05	.01	141.	1.01	23.35	283	.02	.02	.00	61.
1.01	11.40	140	.07	.05	.01	142.	1.01	23.40	284	.02	.02	.00	61.
1.01	11.45	141	.07	.05	.01	142.	1.01	23.45	285	.02	.02	.00	61.
1.01	11.50	142	.07	.05	.01	143.	1.01	23.50	286	.02	.02	.00	61.
1.01	11.55	143	.07	.05	.01	144.	1.01	23.55	287	.02	.02	.00	61.
1.01	12.00	144	.07	.05	.01	144.	1.02	0.00	288	.02	.02	.00	61.

SUM 34.45 30.26 4.19 84639.
(875.)(769.)(106.)(2396.71)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2458.	974.	294.	294.	84624.
CMS	70.	28.	8.	8.	2396.
INCHES		25.01	30.16	30.16	30.16
MM		635.13	766.09	766.09	766.09
AC-FT		483.	583.	583.	583.
THOUS CU M		596.	719.	719.	719.

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**********          **********          **********          **********          **********

                                   HYDROGRAPH ROUTING

              ROUTING OF PMF THROUGH RESERVOIR OF DAM ID # 31080

                     ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                      LAKE        1        0        0        1        1        1        0        0
                                                ROUTING DATA
              QLOSS    CLOSS      AVG     IRES    ISAME     IOPT     IPMP              LSTR
                0.0    0.000     0.00        1        1        0        0                 0

              NSTPS    NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                  1        0        0    0.000    0.000    0.000    -856.       -1

STAGE        856.00    857.10    858.40    859.70    861.00    863.00    863.90    864.50    865.00    866.50

FLOW           0.00      9.00     63.00    161.00    291.00    635.00    840.00   1106.00   1579.00   5713.00

SURFACE AREA=      0.        5.       13.       19.       23.       28.       39.       59.

CAPACITY=          0.       17.      101.      195.      279.      377.      584.     1069.

ELEVATION=       830.      840.      850.      856.      860.      864.      870.      880.

                CREL    SPWID     COQW     EXPW    ELEVL     COQL    CAREA     EXPL
               856.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

                                           DAM DATA
                                 TOPEL     COQD     EXPD   DAMWID
                                 863.8      0.0      0.0       0.


**********          **********          **********          **********          **********

                                 SUB-AREA RUNOFF COMPUTATION

              PMF INFLOW FROM LOCAL DRAINAGE AREA

                     ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO

                     L FLO        0        0        0        1        1        1        0        0
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HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.35	0.00	.35	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	26.50	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-78.00	0.00	.26

CURVE NO = -78.00 WETNESS = -1.00 EFFECT CN = 78.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= .24

RECESSION DATA
STRTQ= -10.00 QRCSN= -.10 RTIOR= 2.50

UNIT HYDROGRAPH 16 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= .24 VOL= 1.00

113.	391.	597.	571.	425.	247.	154.	95.	59.	36.
22.	14.	9.	6.	3.	2.				

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	4.	1.01	12.05	145	.23	.21	.02	181.
1.01	.10	2	.01	.00	.01	5.	1.01	12.10	146	.23	.21	.02	238.
1.01	.15	3	.01	.00	.01	7.	1.01	12.15	147	.23	.21	.02	326.
1.01	.20	4	.01	.00	.01	9.	1.01	12.20	148	.23	.21	.02	410.
1.01	.25	5	.01	.00	.01	10.	1.01	12.25	149	.23	.21	.02	473.
1.01	.30	6	.01	.00	.01	11.	1.01	12.30	150	.23	.21	.02	511.
1.01	.35	7	.01	.00	.01	11.	1.01	12.35	151	.23	.21	.01	536.
1.01	.40	8	.01	.00	.01	12.	1.01	12.40	152	.23	.21	.01	552.
1.01	.45	9	.01	.00	.01	12.	1.01	12.45	153	.23	.21	.01	562.
1.01	.50	10	.01	.00	.01	12.	1.01	12.50	154	.23	.21	.01	569.
1.01	.55	11	.01	.00	.01	12.	1.01	12.55	155	.23	.21	.01	575.
1.01	1.00	12	.01	.00	.01	12.	1.01	13.00	156	.23	.21	.01	578.
1.01	1.05	13	.01	.00	.01	12.	1.01	13.05	157	.27	.26	.01	586.
1.01	1.10	14	.01	.00	.01	11.	1.01	13.10	158	.27	.26	.01	615.
1.01	1.15	15	.01	.00	.01	11.	1.01	13.15	159	.27	.26	.01	633.
1.01	1.20	16	.01	.00	.01	11.	1.01	13.20	160	.27	.26	.01	659.
1.01	1.25	17	.01	.00	.01	11.	1.01	13.25	161	.27	.26	.01	679.
1.01	1.30	18	.01	.00	.01	11.	1.01	13.30	162	.27	.26	.01	691.
1.01	1.35	19	.01	.00	.01	11.	1.01	13.35	163	.27	.26	.01	699.
1.01	1.40	20	.01	.00	.01	11.	1.01	13.40	164	.27	.26	.01	705.
1.01	1.45	21	.01	.00	.01	11.	1.01	13.45	165	.27	.26	.01	708.
1.01	1.50	22	.01	.00	.01	11.	1.01	13.50	166	.27	.26	.01	711.
1.01	1.55	23	.01	.00	.01	11.	1.01	13.55	167	.27	.26	.01	713.
1.01	2.00	24	.01	.00	.01	11.	1.01	14.00	168	.27	.26	.01	715.
1.01	2.05	25	.01	.00	.01	11.	1.01	14.05	169	.34	.33	.01	724.
1.01	2.10	26	.01	.00	.01	11.	1.01	14.10	170	.34	.33	.01	751.
1.01	2.15	27	.01	.00	.01	11.	1.01	14.15	171	.34	.33	.01	791.
1.01	2.20	28	.01	.00	.01	11.	1.01	14.20	172	.34	.33	.01	830.
1.01	2.25	29	.01	.00	.01	11.	1.01	14.25	173	.34	.33	.01	859.
1.01	2.30	30	.01	.00	.01	11.	1.01	14.30	174	.34	.33	.01	876.
1.01	2.35	31	.01	.00	.01	11.	1.01	14.35	175	.34	.33	.01	887.

1.01	2.40	32	.01	.00	.01	11.	1.01	14.40	176	.34	.33	.01	895.
1.01	2.45	33	.01	.00	.01	11.	1.01	14.45	177	.34	.33	.01	899.
1.01	2.50	34	.01	.00	.01	11.	1.01	14.50	178	.34	.33	.01	903.
1.01	2.55	35	.01	.00	.01	11.	1.01	14.55	179	.34	.33	.01	905.
1.01	3.00	36	.01	.00	.01	11.	1.01	15.00	180	.34	.33	.01	907.
1.01	3.05	37	.01	.00	.01	11.	1.01	15.05	181	.21	.20	.00	893.
1.01	3.10	38	.01	.00	.01	11.	1.01	15.10	182	.41	.40	.01	866.
1.01	3.15	39	.01	.00	.01	11.	1.01	15.15	183	.41	.40	.01	869.
1.01	3.20	40	.01	.00	.01	11.	1.01	15.20	184	.62	.61	.01	938.
1.01	3.25	41	.01	.00	.01	11.	1.01	15.25	185	.72	.71	.01	1090.
1.01	3.30	42	.01	.00	.01	11.	1.01	15.30	186	1.75	1.72	.02	1419.
1.01	3.35	43	.01	.00	.01	11.	1.01	15.35	187	2.88	2.85	.03	2150.
1.01	3.40	44	.01	.00	.01	11.	1.01	15.40	188	1.13	1.12	.01	3162.
1.01	3.45	45	.01	.00	.01	11.	1.01	15.45	189	.72	.71	.01	3795.
1.01	3.50	46	.01	.00	.01	12.	1.01	15.50	190	.62	.61	.00	3731.
1.01	3.55	47	.01	.00	.01	12.	1.01	15.55	191	.41	.41	.00	3208.
1.01	4.00	48	.01	.00	.01	12.	1.01	16.00	192	.41	.41	.00	2560.
1.01	4.05	49	.01	.00	.01	13.	1.01	16.05	193	.32	.31	.00	2055.
1.01	4.10	50	.01	.00	.01	13.	1.01	16.10	194	.32	.31	.00	1668.
1.01	4.15	51	.01	.01	.01	13.	1.01	16.15	195	.32	.31	.00	1381.
1.01	4.20	52	.01	.01	.01	13.	1.01	16.20	196	.32	.31	.00	1147.
1.01	4.25	53	.01	.01	.01	14.	1.01	16.25	197	.32	.31	.00	1061.
1.01	4.30	54	.01	.01	.01	14.	1.01	16.30	198	.32	.31	.00	984.
1.01	4.35	55	.01	.01	.01	14.	1.01	16.35	199	.32	.31	.00	937.
1.01	4.40	56	.01	.01	.01	14.	1.01	16.40	200	.32	.31	.00	908.
1.01	4.45	57	.01	.01	.01	15.	1.01	16.45	201	.32	.31	.00	889.
1.01	4.50	58	.01	.01	.01	15.	1.01	16.50	202	.32	.31	.00	875.
1.01	4.55	59	.01	.01	.01	15.	1.01	16.55	203	.32	.31	.00	867.
1.01	5.00	60	.01	.01	.01	15.	1.01	17.00	204	.32	.31	.00	863.
1.01	5.05	61	.01	.01	.01	16.	1.01	17.05	205	.25	.25	.00	854.
1.01	5.10	62	.01	.01	.01	16.	1.01	17.10	206	.25	.25	.00	827.
1.01	5.15	63	.01	.01	.01	16.	1.01	17.15	207	.25	.25	.00	787.
1.01	5.20	64	.01	.01	.01	16.	1.01	17.20	208	.25	.25	.00	748.
1.01	5.25	65	.01	.01	.01	17.	1.01	17.25	209	.25	.25	.00	720.
1.01	5.30	66	.01	.01	.01	17.	1.01	17.30	210	.25	.25	.00	703.
1.01	5.35	67	.01	.01	.01	17.	1.01	17.35	211	.25	.25	.00	693.
1.01	5.40	68	.01	.01	.01	17.	1.01	17.40	212	.25	.25	.00	687.
1.01	5.45	69	.01	.01	.01	17.	1.01	17.45	213	.25	.25	.00	683.
1.01	5.50	70	.01	.01	.01	18.	1.01	17.50	214	.25	.25	.00	680.
1.01	5.55	71	.01	.01	.01	18.	1.01	17.55	215	.25	.25	.00	679.
1.01	6.00	72	.01	.01	.01	18.	1.01	18.00	216	.25	.25	.00	678.
1.01	6.05	73	.07	.03	.03	21.	1.01	18.05	217	.02	.02	.00	652.
1.01	6.10	74	.07	.03	.03	31.	1.01	18.10	218	.02	.02	.00	564.
1.01	6.15	75	.07	.03	.03	46.	1.01	18.15	219	.02	.02	.00	430.
1.01	6.20	76	.07	.04	.03	62.	1.01	18.20	220	.02	.02	.00	359.
1.01	6.25	77	.07	.04	.03	75.	1.01	18.25	221	.02	.02	.00	328.
1.01	6.30	78	.07	.04	.03	83.	1.01	18.30	222	.02	.02	.00	299.
1.01	6.35	79	.07	.04	.03	90.	1.01	18.35	223	.02	.02	.00	273.
1.01	6.40	80	.07	.04	.03	95.	1.01	18.40	224	.02	.02	.00	249.
1.01	6.45	81	.07	.04	.03	99.	1.01	18.45	225	.02	.02	.00	227.
1.01	6.50	82	.07	.04	.03	103.	1.01	18.50	226	.02	.02	.00	207.
1.01	6.55	83	.07	.04	.02	106.	1.01	18.55	227	.02	.02	.00	189.
1.01	7.00	84	.07	.04	.02	109.	1.01	19.00	228	.02	.02	.00	173.
1.01	7.05	85	.07	.04	.02	112.	1.01	19.05	229	.02	.02	.00	158.
1.01	7.10	86	.07	.04	.02	114.	1.01	19.10	230	.02	.02	.00	144.
1.01	7.15	87	.07	.04	.02	116.	1.01	19.15	231	.02	.02	.00	131.
1.01	7.20	88	.07	.05	.02	117.	1.01	19.20	232	.02	.02	.00	120.
1.01	7.25	89	.07	.05	.02	121.	1.01	19.25	233	.02	.02	.00	109.
1.01	7.30	90	.07	.05	.02	122.	1.01	19.30	234	.02	.02	.00	100.
1.01	7.35	91	.07	.05	.02	124.	1.01	19.35	235	.02	.02	.00	91.

1.01	7.40	92	.07	.05	.02	126.	1.01	19.40	236	.02	.02	.00	83.
1.01	7.45	93	.07	.05	.02	128.	1.01	19.45	237	.02	.02	.00	76.
1.01	7.50	94	.07	.05	.02	129.	1.01	19.50	238	.02	.02	.00	69.
1.01	7.55	95	.07	.05	.02	131.	1.01	19.55	239	.02	.02	.00	63.
1.01	8.00	96	.07	.05	.02	132.	1.01	20.00	240	.02	.02	.00	60.
1.01	8.05	97	.07	.05	.02	134.	1.01	20.05	241	.02	.02	.00	60.
1.01	8.10	98	.07	.05	.02	135.	1.01	20.10	242	.02	.02	.00	60.
1.01	8.15	99	.07	.05	.02	136.	1.01	20.15	243	.02	.02	.00	60.
1.01	8.20	100	.07	.05	.01	137.	1.01	20.20	244	.02	.02	.00	60.
1.01	8.25	101	.07	.05	.01	139.	1.01	20.25	245	.02	.02	.00	60.
1.01	8.30	102	.07	.05	.01	140.	1.01	20.30	246	.02	.02	.00	60.
1.01	8.35	103	.07	.05	.01	141.	1.01	20.35	247	.02	.02	.00	60.
1.01	8.40	104	.07	.05	.01	142.	1.01	20.40	248	.02	.02	.00	60.
1.01	8.45	105	.07	.05	.01	143.	1.01	20.45	249	.02	.02	.00	60.
1.01	8.50	106	.07	.05	.01	144.	1.01	20.50	250	.02	.02	.00	60.
1.01	8.55	107	.07	.05	.01	145.	1.01	20.55	251	.02	.02	.00	60.
1.01	9.00	108	.07	.05	.01	146.	1.01	21.00	252	.02	.02	.00	60.
1.01	9.05	109	.07	.05	.01	147.	1.01	21.05	253	.02	.02	.00	60.
1.01	9.10	110	.07	.05	.01	147.	1.01	21.10	254	.02	.02	.00	60.
1.01	9.15	111	.07	.05	.01	148.	1.01	21.15	255	.02	.02	.00	60.
1.01	9.20	112	.07	.06	.01	149.	1.01	21.20	256	.02	.02	.00	60.
1.01	9.25	113	.07	.06	.01	150.	1.01	21.25	257	.02	.02	.00	60.
1.01	9.30	114	.07	.06	.01	150.	1.01	21.30	258	.02	.02	.00	60.
1.01	9.35	115	.07	.06	.01	151.	1.01	21.35	259	.02	.02	.00	60.
1.01	9.40	116	.07	.06	.01	152.	1.01	21.40	260	.02	.02	.00	60.
1.01	9.45	117	.07	.06	.01	152.	1.01	21.45	261	.02	.02	.00	60.
1.01	9.50	118	.07	.06	.01	153.	1.01	21.50	262	.02	.02	.00	60.
1.01	9.55	119	.07	.06	.01	154.	1.01	21.55	263	.02	.02	.00	60.
1.01	10.00	120	.07	.06	.01	154.	1.01	22.00	264	.02	.02	.00	60.
1.01	10.05	121	.07	.06	.01	155.	1.01	22.05	265	.02	.02	.00	60.
1.01	10.10	122	.07	.06	.01	155.	1.01	22.10	266	.02	.02	.00	60.
1.01	10.15	123	.07	.06	.01	156.	1.01	22.15	267	.02	.02	.00	60.
1.01	10.20	124	.07	.06	.01	157.	1.01	22.20	268	.02	.02	.00	60.
1.01	10.25	125	.07	.06	.01	157.	1.01	22.25	269	.02	.02	.00	60.
1.01	10.30	126	.07	.06	.01	158.	1.01	22.30	270	.02	.02	.00	60.
1.01	10.35	127	.07	.06	.01	158.	1.01	22.35	271	.02	.02	.00	60.
1.01	10.40	128	.07	.06	.01	158.	1.01	22.40	272	.02	.02	.00	60.
1.01	10.45	129	.07	.06	.01	159.	1.01	22.45	273	.02	.02	.00	60.
1.01	10.50	130	.07	.06	.01	159.	1.01	22.50	274	.02	.02	.00	60.
1.01	10.55	131	.07	.06	.01	160.	1.01	22.55	275	.02	.02	.00	60.
1.01	11.00	132	.07	.06	.01	160.	1.01	23.00	276	.02	.02	.00	60.
1.01	11.05	133	.07	.06	.01	161.	1.01	23.05	277	.02	.02	.00	60.
1.01	11.10	134	.07	.06	.01	161.	1.01	23.10	278	.02	.02	.00	60.
1.01	11.15	135	.07	.06	.01	161.	1.01	23.15	279	.02	.02	.00	60.
1.01	11.20	136	.07	.06	.01	162.	1.01	23.20	280	.02	.02	.00	60.
1.01	11.25	137	.07	.06	.01	162.	1.01	23.25	281	.02	.02	.00	60.
1.01	11.30	138	.07	.06	.01	162.	1.01	23.30	282	.02	.02	.00	60.
1.01	11.35	139	.07	.06	.01	163.	1.01	23.35	283	.02	.02	.00	60.
1.01	11.40	140	.07	.06	.01	163.	1.01	23.40	284	.02	.02	.00	60.
1.01	11.45	141	.07	.06	.01	163.	1.01	23.45	285	.02	.02	.00	60.
1.01	11.50	142	.07	.06	.01	164.	1.01	23.50	286	.02	.02	.00	60.
1.01	11.55	143	.07	.06	.01	164.	1.01	23.55	287	.02	.02	.00	60.
1.01	12.00	144	.07	.06	.01	164.	1.02	0.00	288	.02	.02	.00	60.

SUM 34.45 32.11 2.34 89584.
(875.)(815.)(60.)(2536.74)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3795.	997.	311.	311.	89569.
CMS	107.	28.	9.	9.	2536.
INCHES		26.16	32.63	32.63	32.63
MM		664.45	828.69	828.69	828.69
AC-FT		495.	617.	617.	617.
THOUS CU M		610.	761.	761.	761.

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COMBINE HYDROGRAPHS

COMBINED PMF FROM LOCAL INFLOW & OUTFLOW FROM UPPER RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
COMBD	2	0	0	1	1	1	0	0

SUM OF 2 HYDROGRAPHS AT COMBD PLAN 1 RTIO 3

4.	5.	7.	9.	10.	11.	11.	12.	12.	12.
12.	12.	12.	12.	12.	11.	11.	11.	11.	11.
11.	11.	11.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	11.	11.	11.	11.	11.	11.	11.
11.	11.	11.	12.	12.	12.	13.	13.	13.	13.
14.	14.	14.	15.	15.	15.	15.	16.	16.	16.
16.	17.	17.	17.	17.	17.	18.	18.	18.	18.
19.	19.	22.	32.	47.	63.	76.	84.	91.	96.
101.	104.	108.	110.	113.	116.	118.	121.	123.	125.
127.	129.	131.	132.	134.	136.	137.	139.	140.	142.
143.	145.	146.	147.	149.	150.	151.	152.	153.	155.
156.	157.	158.	159.	160.	161.	163.	165.	167.	169.
172.	174.	176.	178.	180.	182.	184.	186.	188.	189.
191.	193.	195.	197.	199.	200.	202.	204.	205.	207.
209.	210.	212.	214.	232.	290.	379.	465.	530.	570.
597.	618.	635.	649.	662.	674.	690.	718.	754.	789.
818.	839.	857.	874.	891.	906.	921.	935.	957.	996.
1048.	1090.	1140.	1172.	1204.	1232.	1258.	1282.	1304.	1325.
1332.	1324.	1344.	1431.	1600.	1947.	2698.	3736.	4402.	4366.
3434.	3365.	2986.	2750.	2700.	2711.	2820.	2867.	2786.	2659.
2519.	2427.	2367.	2306.	2237.	2152.	2056.	1965.	1886.	1821.
1782.	1753.	1726.	1699.	1674.	1650.	1602.	1491.	1335.	1241.
1184.	1133.	1089.	1045.	1001.	957.	913.	870.	828.	788.
754.	723.	693.	664.	636.	609.	583.	558.	534.	514.
497.	480.	464.	449.	434.	419.	406.	392.	383.	368.
356.	346.	341.	335.	329.	323.	316.	312.	307.	301.
296.	291.	286.	281.	277.	272.	268.	264.	259.	255.
251.	248.	244.	240.	237.	233.	230.	227.	224.	221.
219.	216.	214.	212.	210.	208.	206.	204.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	4402.	1721.	569.	569.	163778.
CMS	125.	49.	16.	16.	4638.
INCHES		22.32	29.50	29.50	29.50
MM		566.83	749.39	749.39	749.39
AC-FT		853.	1128.	1128.	1128.
THOUS CU M		1052.	1391.	1391.	1391.

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                                   HYDROGRAPH ROUTING

              ROUTING OF COMBINED PMF THROUGH RESERVOIR

                  ISTAQ     ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                  LAKE2         1        0        0        2        1        1        0        0
                                           ROUTING DATA
         QLOSS    CLOSS       AVG     IRES    ISAME     IOPT     IPMP                LSTR
           0.0    0.000      0.00        1        1        0        0                   0

                  NSTPS     NSTDL      LAG    AMSKK        X      TSK    STORA   ISPRAT
                      1         0        0    0.000    0.000    0.000    -833.       -1

STAGE      830.60    831.00    831.50    832.00    832.50    833.00    833.50    834.00    834.50    835.00
           835.70    836.00    836.50    837.00    837.50    838.00    839.00    840.00    841.00

FLOW         0.00      4.00     28.00     53.00     83.00     94.00    120.00    165.00    225.00    310.00
           470.00    730.00   1650.00   3520.00   6320.00   9320.00  16530.00  26030.00  36730.00

SURFACE AREA=      0.       16.       38.       40.       42.       44.       46.       49.       53.       58.

CAPACITY=          0.      109.      453.      492.      533.      563.      622.      669.      771.      882.

ELEVATION=       803.      820.      833.      834.      835.      836.      837.      838.      840.      842.

              CREL    SPWID     COQW     EXPW    ELEVL     COQL    CAREA     EXPL
             833.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

                                  DAM DATA
                        TOPEL     COQD     EXPD    DAMWID
                        835.7      0.0      0.0        0.
```

STATION LAKE2, PLAN 1, RATIO 3

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

94.	93.	93.	93.	92.	92.	92.	91.	91.	91.
90.	90.	90.	89.	89.	89.	88.	88.	88.	88.
87.	87.	87.	86.	86.	86.	85.	85.	85.	84.
84.	84.	84.	83.	83.	82.	81.	81.	80.	79.
78.	78.	77.	76.	75.	75.	74.	73.	73.	72.
71.	71.	70.	69.	69.	68.	68.	67.	66.	66.
65.	65.	64.	64.	63.	63.	62.	62.	61.	61.
60.	60.	59.	59.	59.	59.	59.	59.	59.	60.
60.	61.	61.	62.	62.	63.	63.	64.	65.	65.
66.	67.	67.	68.	69.	70.	70.	71.	72.	73.
73.	74.	75.	76.	77.	78.	78.	79.	80.	81.
82.	82.	83.	83.	84.	84.	84.	85.	85.	85.
86.	86.	86.	87.	87.	88.	88.	88.	89.	89.
89.	90.	90.	91.	91.	92.	92.	92.	93.	93.
94.	95.	96.	97.	98.	100.	102.	105.	108.	112.
117.	122.	130.	138.	146.	154.	162.	173.	184.	196.
208.	221.	236.	254.	272.	289.	306.	325.	350.	373.
396.	421.	446.	474.	566.	649.	725.	856.	964.	1051.
1119.	1170.	1210.	1253.	1317.	1430.	1650.	2341.	3096.	3712.
3974.	3784.	3453.	3198.	2493.	2670.	2826.	2835.	2832.	2785.
2700.	2602.	2513.	2436.	2364.	2290.	2209.	2122.	2036.	1956.
1888.	1835.	1793.	1758.	1726.	1698.	1666.	1630.	1579.	1507.
1434.	1368.	1306.	1246.	1193.	1141.	1090.	1042.	994.	948.
904.	863.	825.	788.	754.	726.	710.	692.	674.	655.
637.	618.	600.	582.	564.	547.	530.	513.	497.	481.
469.	465.	461.	456.	452.	448.	443.	439.	434.	429.
425.	420.	415.	411.	406.	401.	397.	392.	387.	383.
378.	373.	369.	364.	360.	355.	351.	346.	342.	337.
333.	329.	325.	321.	317.	313.	309.	306.		

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .68	RATIO 2 .75	RATIO 3 1.00
				RATIOS APPLIED TO FLOWS		
HYDROGRAPH AT	INFLOW	.36	1	1672.	1844.	2458.
	(	.94)	(	47.35)(	52.21)(	69.61)(
ROUTED TO	LAKE	.36	1	820.	981.	1882.
	(	.94)	(	23.22)(	27.77)(	53.30)(
HYDROGRAPH AT	L FLO	.35	1	2581.	2845.	3795.
	(	.92)	(	73.07)(	80.60)(	107.46)(
2 COMBINED	COMBO	.72	1	2933.	3260.	4402.
	(	1.86)	(	83.05)(	92.32)(	124.66)(
ROUTED TO	LAKE2	.72	1	2198.	2661.	3974.
	(	1.86)	(	62.24)(	75.36)(	112.54)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	856.00	856.00	863.80
STORAGE	195.	195.	377.
OUTFLOW	0.	0.	817.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.68	863.81	.01	377.	820.	.25	16.92	0.00
.75	864.22	.42	389.	981.	1.42	16.83	0.00
1.00	865.11	1.31	415.	1882.	2.50	16.50	0.00

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	833.00	833.00	835.70
STORAGE	453.	453.	563.
OUTFLOW	94.	94.	470.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.68	836.65	.95	605.	2198.	4.67	16.00	0.00
.75	836.77	1.07	611.	2661.	5.08	16.00	0.00
1.00	837.08	1.38	625.	3974.	6.42	15.92	0.00

```
A1        ANCHUTZ TAILING DAM ID NO 31082
A2        HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3        RATIOS OF PMF ROUTED THROUGH RESERVOIR
B      288               5
B1       5
J        1       2       1
J1     .55     .60
K        0INFLOW                          1       1       1
K1INFLOW FROM DRAINAGE AREA ABOVE DAM ID # 31080
M        1       2   .3625                        1                       1
P        0    26.5     102     120     130
T                                                        -1     -70              .1
W2              .6
X      -10     -.1     2.5
K        1  LAKE                          1       1       1
K1ROUTING OF PMF THROUGH RESERVOIR OF DAM ID # 31080
Y                                1       1
Y1       1                                           -856.0      -1
Y4   856.0   857.1   858.4   859.7   861.0   863.0   863.9   864.5   865.0   866.5
Y5       0       9      63     161     291     635     840    1106    1579    5713
$A       0       5    12.5      19      23    28.4    38.7      59
$E     830     840     850     856     860   863.8     870     880
$$   856.0
$D   863.8
K       99
A
A
A
A
A
```

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE* 79/07/20.
     TIME* 10.08.07.

                         ANCHUTZ TAILING DAM ID NO 31082
                         HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
                         RATIOS OF PMF ROUTED THROUGH RESERVOIR

                                      JOB SPECIFICATION
          NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
         288       0       5       0       0       0       0       0       0       0
                                JOPER     NWT   LROPT   TRACE
                                    5       0       0       0

                              MULTI-PLAN ANALYSES TO BE PERFORMED
                                NPLAN= 1 NRTIO= 2 LRTIO= 1

          RTIOS=    .55    .60


   **********        **********        **********        **********        **********

                                SUB-AREA RUNOFF COMPUTATION

        INFLOW FROM DRAINAGE AREA ABOVE DAM ID # 31080

                    ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                   INFLOW       0       0       0       1       1       1       0       0

                                      HYDROGRAPH DATA
          IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
              1       2     .36    0.00     .36    1.00   0.000       0       1       0

                                        PRECIP DATA
                   SPFE     PMS      R6     R12     R24     R48     R72     R96
                   0.00   26.50  102.00  120.00  130.00    0.00    0.00    0.00

                                         LOSS DATA
        LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
            0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -70.00    0.00     .10

          CURVE NO =  -70.00  WETNESS =   -1.00  EFFECT CN =   70.00

                                    UNIT HYDROGRAPH DATA
                                 TC=   0.00    LAG=    .60

                                       RECESSION DATA
                          STRTQ=  -10.00   QRCSN=   -.10   RTIOR= 2.50

        UNIT HYDROGRAPH 38 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .60  VOL= 1.00
           14.      42.      81.     138.     202.     248.     270.     272.     259.     235.
          205.     166.     129.     103.      84.      69.      56.      45.      36.      29.
           24.      19.      15.      13.      10.       8.       7.       5.       4.       4.
            3.       2.       2.       2.       1.       1.       1.       0.
```

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 1

2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	3.	3.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	3.	3.	3.
3.	3.	3.	4.	4.	5.	7.	8.	11.	13.
15.	18.	20.	23.	25.	27.	29.	31.	33.	35.
37.	38.	40.	42.	43.	45.	46.	47.	49.	50.
51.	52.	53.	54.	56.	57.	58.	58.	59.	60.
61.	62.	63.	64.	64.	65.	66.	67.	67.	68.
69.	69.	70.	70.	71.	71.	72.	73.	73.	74.
74.	75.	75.	75.	76.	76.	77.	77.	78.	78.
78.	79.	79.	79.	81.	84.	90.	101.	115.	134.
154.	175.	194.	213.	229.	242.	254.	264.	273.	283.
293.	304.	314.	324.	333.	342.	349.	355.	361.	367.
373.	381.	391.	403.	414.	426.	437.	447.	456.	463.
468.	472.	475.	479.	486.	514.	576.	675.	809.	974.
1139.	1265.	1337.	1352.	1321.	1254.	1162.	1052.	946.	859.
786.	730.	682.	643.	611.	584.	561.	539.	518.	499.
480.	463.	448.	435.	424.	415.	406.	395.	381.	360.
332.	298.	263.	228.	194.	165.	139.	125.	114.	104.
95.	87.	79.	72.	66.	60.	55.	50.	46.	42.
39.	38.	37.	36.	36.	35.	35.	34.	34.	34.
34.	34.	34.	34.	34.	34.	34.	34.	34.	34.
34.	34.	34.	34.	34.	34.	34.	34.	34.	34.
34.	34.	34.	34.	34.	34.	34.	34.	34.	34.
34.	34.	34.	34.	34.	34.	34.	34.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1352.	536.	162.	162.	46543.
CMS	38.	15.	5.	5.	1316.
INCHES		13.75	16.59	16.59	16.59
MM		349.32	421.35	421.35	421.35
AC-FT		266.	321.	321.	321.
THOUS CU M		328.	395.	395.	395.

HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 2

2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	4.	4.	6.	7.	9.	12.	14.
17.	20.	22.	25.	27.	30.	32.	34.	36.	38.
40.	42.	44.	45.	47.	49.	50.	52.	53.	54.
56.	57.	58.	59.	61.	62.	65.	64.	65.	66.
67.	68.	69.	69.	70.	71.	72.	73.	73.	74.
75.	75.	76.	77.	77.	78.	79.	79.	80.	80.
81.	81.	82.	82.	83.	83.	84.	84.	85.	85.
85.	85.	86.	87.	88.	92.	98.	110.	126.	146.
168.	190.	212.	232.	250.	264.	277.	288.	298.	309.
320.	332.	343.	354.	364.	373.	381.	387.	394.	400.
407.	416.	427.	439.	452.	465.	477.	488.	497.	505.
511.	515.	518.	523.	533.	561.	628.	736.	882.	1063.
1243.	1381.	1458.	1475.	1441.	1369.	1267.	1148.	1032.	937.
859.	796.	744.	702.	667.	638.	612.	588.	565.	544.
524.	505.	489.	474.	462.	452.	443.	431.	415.	392.
362.	325.	287.	248.	212.	180.	151.	137.	125.	114.
104.	95.	87.	79.	72.	66.	60.	55.	50.	46.
42.	41.	40.	39.	39.	38.	38.	38.	37.	37.
37.	37.	37.	37.	37.	37.	37.	37.	37.	37.
37.	37.	37.	37.	37.	37.	37.	37.	37.	37.
37.	37.	37.	37.	37.	37.	37.	37.	37.	37.
37.	37.	37.	37.	37.	37.	37.	37.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1475.	585.	176.	176.	59774.
CMS	42.	17.	5.	5.	1434.
INCHES		15.00	18.10	18.10	18.10
MM		381.08	459.65	459.65	459.65
AC-FT		290.	350.	350.	350.
THOUS CU M		358.	431.	431.	431.

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**********          **********          **********          **********          **********

                                      HYDROGRAPH ROUTING

              ROUTING OF PMF THROUGH RESERVOIR OF DAM ID # 31080

                     ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                      LAKE       1       0       0       1       1       1       0       0
                                              ROUTING DATA
              QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                0.0   0.000    0.00       1       1       0       0               0

                     NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                         1       0       0   0.000   0.000   0.000   -856.      -1

STAGE       856.00      857.10      858.40      859.70      861.00      863.00      863.90      864.50      865.00      866.50

FLOW          0.00        9.00       63.00      161.00      291.00      635.00      840.00     1106.00     1579.00     5713.00

SURFACE AREA=      0.         5.        13.        19.        23.        28.        39.        59.

CAPACITY=          0.        17.       101.       195.       279.       377.       584.      1069.

ELEVATION=       830.       840.       850.       856.       860.       864.       870.       880.

                      CREL   SPWID   COQW    EXPW   ELEVL    COQL   CAREA    EXPL
                     856.0     0.0    0.0     0.0     0.0     0.0     0.0     0.0

                                          DAM DATA
                                 TOPEL    COQD    EXPD   DAMWID
                                 863.8     0.0     0.0       0.
```

STATION LAKE, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	2.	2.	2.	2.	2.	2.	2.	2.
3.	3.	3.	3.	3.	3.	4.	4.	4.	4.
4.	4.	4.	5.	5.	5.	5.	5.	6.	6.
6.	6.	6.	6.	7.	7.	7.	7.	7.	8.
8.	8.	8.	8.	8.	9.	9.	9.	10.	11.
12.	13.	14.	15.	16.	17.	18.	19.	20.	22.
23.	25.	27.	30.	32.	35.	38.	41.	44.	47.
51.	54.	57.	61.	66.	72.	79.	85.	92.	98.
104.	111.	117.	124.	130.	137.	144.	151.	157.	165.
174.	185.	192.	206.	208.	217.	226.	238.	252.	270.
293.	336.	381.	425.	460.	503.	534.	559.	578.	592.
602.	609.	613.	615.	616.	615.	613.	610.	607.	603.
594.	592.	590.	590.	574.	567.	560.	555.	540.	536.
530.	520.	510.	498.	485.	472.	457.	443.	426.	413.
399.	385.	371.	357.	344.	331.	318.	306.	293.	285.
279.	272.	265.	259.	252.	246.	240.	234.	229.	223.
217.	212.	207.	202.	197.	192.	187.	183.	178.	174.
[illegible]	166.	162.	159.	156.	155.	151.	148.	145.	143.
[illegible]	138.	135.	133.	131.	129.	126.	124.	122.	120.
116.	116.	114.	112.	110.	109.	107.	105.		

STATION LAKE, PLAN 1, RATIO 2

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	[illegible]	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
2.	2.	2.	2.	2.	2.	2.	2.	3.	3.
3.	3.	3.	3.	3.	4.	4.	4.	4.	4.
5.	5.	5.	5.	5.	5.	6.	6.	6.	6.
6.	7.	7.	7.	7.	7.	8.	8.	8.	8.
8.	9.	9.	9.	10.	11.	12.	13.	14.	15.
16.	17.	18.	19.	20.	21.	22.	23.	25.	26.
24.	30.	32.	35.	38.	41.	44.	47.	50.	54.
57.	61.	66.	73.	79.	86.	93.	100.	107.	114.
120.	127.	134.	141.	148.	155.	162.	172.	181.	191.
200.	209.	218.	227.	236.	244.	254.	267.	282.	305.
348.	392.	439.	485.	528.	567.	599.	625.	648.	667.
680.	688.	693.	694.	694.	691.	688.	683.	677.	670.
663.	654.	646.	636.	629.	622.	614.	607.	599.	590.
581.	571.	559.	547.	533.	518.	502.	486.	470.	455.
439.	424.	409.	394.	379.	365.	351.	337.	324.	311.
296.	288.	281.	274.	268.	261.	255.	249.	243.	237.
231.	225.	220.	215.	210.	204.	200.	195.	190.	186.
181.	177.	173.	169.	165.	161.	158.	155.	153.	150.
147.	145.	142.	140.	138.	135.	133.	131.	129.	127.
125.	122.	121.	119.	117.	115.	113.	111.		

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .45	RATIO 2 .50
HYDROGRAPH AT	[illegible]	.36	1	1552.	1475.
	(	.94)	(	38.29)(	41.77)(
ROUTED TO	LAKE	.36	1	616.	694.
	(	.94)	(	17.43)(	19.65)(

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A1          ANCHOLZ TAILING DAM ID NO 31082
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3          55 % PMF ROUTED THROUGH RESERVOIR
B     288                  5
B1      5
J       1         1        1
J1   0.55
K       0  LOC FL                                1         1         1
K1 55 % PMF INFLOW FROM LOCAL DRAINAGE AREA
M       1         2   0.3016                               1                             1
P       0      26.5      102       120       130
T                                                                    -1       -78                 0.3
W2             0.24
X     -10        -.1      2.5
K       0  EM SPW                                                    1
K1 55 % PMF OUTFLOW FROM EMERGENCY SPILLWAY OF UPSTREAM DAM # 31080
M      -1         2   0.3016                               1                             1
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
```

```
N      0.       0.       0.    1.82    1.82    1.82    1.82    1.82    5.45    7.27
N  10.91    21.82    30.91   49.09   65.45   81.82   98.18  116.36  123.64  127.27
N 130.91   136.36   140.00  141.82  143.64  145.45  147.27  147.27  138.18  136.36
N 134.55   132.72   127.27  120.00  116.36  114.55  112.73  109.09  105.45  101.82
N  98.18    94.55    90.91   81.82   74.55   69.09   65.45   56.36   49.09   43.64
N  38.18    34.55    30.91   27.27   21.82   20.00   18.18   14.55   12.72   10.91
N   9.09     7.27     5.45    5.45    5.45    3.64    1.82    1.82    1.82    1.82
N   1.82     1.82     1.82    1.82      0.      0.      0.      0.      0.      0.
N
N
N
N
K      2  COMBND                                         1
K1 COMBINED FLOW FROM LOCAL PMF & OUTFLOW FROM EMERGENCY SPILLWAY UPSTREAM
K      1   L LAKE                               1       1       1
K1 ROUTING OF COMBINED PMF THROUGH RESERVOIR
Y                                       1       1
Y1     1                                               -833.      -1
Y4 830.6    831.0    831.5   832.0   832.5   833.0   833.5   834.0   834.5   835.0
Y4 835.7    836.0    836.5   837.0   837.5   838.0   839.0   840.0   841.0
Y5   0.0       8.      28.     53.     83.     94.    120.    165.    225.    310.
Y5  470.     730.    1650.   3520.   6320.   9320.  16530.  20030.  36730.
$A    0.     10.4     38.0    40.0    42.0    43.5    46.4    48.7    53.3    58.0
$E  800.     820.     833.    834.    835.   835.7    837.    838.    840.    842.
$$ 833.0
$D 835.7




K     99
```

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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************

RUN  DATE* 79/08/21.
     TIME* 14.10.10.

                    ANCHUTZ TAILING DAM ID NO 31082
                    HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
                    55 % PMF ROUTED THROUGH RESERVOIR

                                 JOB SPECIFICATION
      NQ     NHR    NMIN    IDAY    IHR    IMIN   METRC    IPLT    IPRT   NSTAN
     288       0       5       0      0       0       0       0       0       0
                            JOPER    NWT   LROPT   TRACE
                               5       0       0       0

                        MULTI-PLAN ANALYSES TO BE PERFORMED
                           NPLAN= 1 NRTIO= 1 LRTIO= 1
     RTIOS=    .55

**********        **********        **********        **********        **********

                              SUB-AREA RUNOFF COMPUTATION

     55 % PMF INFLOW FROM LOCAL DRAINAGE AREA

              ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
             LOC FL       0       0       0       1       1       1       0       0

                                 HYDROGRAPH DATA
     IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
         1      2     .30    0.00     .30    1.00   0.000       0       1       0

                                   PRECIP DATA
              SPFE     PMS      R6     R12     R24     R48     R72     R96
              0.00   26.50  102.00  120.00  130.00    0.00    0.00    0.00

                                    LOSS DATA
  LROPT  STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
      0   0.10   0.00   1.00   0.00   0.00   1.00  -1.00 -78.00   0.00    .30

     CURVE NO =  -78.00  WETNESS =   -1.00  EFFECT CN =   78.00

                              UNIT HYDROGRAPH DATA
                          TC=   0.00    LAG=    .24

                                 RECESSION DATA
                STRTQ=  -10.00    QRCSN=    -.10    RTIOR= 2.50

     UNIT HYDROGRAPH 16 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=   .24  VOL= 1.00
    95.     333.     507.     485.     362.     219.     131.      81.      50.      31.
    19.      12.       7.       5.       3.       1.
```

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	3.	1.01	12.05	145	.23	.21	.02	155.
1.01	.10	2	.01	.00	.01	4.	1.01	12.10	146	.23	.21	.02	204.
1.01	.15	3	.01	.00	.01	6.	1.01	12.15	147	.23	.21	.02	278.
1.01	.20	4	.01	.00	.01	8.	1.01	12.20	148	.23	.21	.02	350.
1.01	.25	5	.01	.00	.01	10.	1.01	12.25	149	.23	.21	.02	404.
1.01	.30	6	.01	.00	.01	11.	1.01	12.30	150	.23	.21	.01	437.
1.01	.35	7	.01	.00	.01	11.	1.01	12.35	151	.23	.21	.01	458.
1.01	.40	8	.01	.00	.01	11.	1.01	12.40	152	.23	.21	.01	471.
1.01	.45	9	.01	.00	.01	11.	1.01	12.45	153	.23	.21	.01	480.
1.01	.50	10	.01	.00	.01	11.	1.01	12.50	154	.23	.21	.01	486.
1.01	.55	11	.01	.00	.01	11.	1.01	12.55	155	.23	.21	.01	490.
1.01	1.00	12	.01	.00	.01	11.	1.01	13.00	156	.23	.21	.01	493.
1.01	1.05	13	.01	.00	.01	11.	1.01	13.05	157	.27	.26	.01	500.
1.01	1.10	14	.01	.00	.01	11.	1.01	13.10	158	.27	.26	.01	516.
1.01	1.15	15	.01	.00	.01	11.	1.01	13.15	159	.27	.26	.01	540.
1.01	1.20	16	.01	.00	.01	11.	1.01	13.20	160	.27	.26	.01	562.
1.01	1.25	17	.01	.00	.01	11.	1.01	13.25	161	.27	.26	.01	579.
1.01	1.30	18	.01	.00	.01	11.	1.01	13.30	162	.27	.26	.01	589.
1.01	1.35	19	.01	.00	.01	11.	1.01	13.35	163	.27	.26	.01	596.
1.01	1.40	20	.01	.00	.01	11.	1.01	13.40	164	.27	.26	.01	601.
1.01	1.45	21	.01	.00	.01	11.	1.01	13.45	165	.27	.26	.01	604.
1.01	1.50	22	.01	.00	.01	11.	1.01	13.50	166	.27	.26	.01	606.
1.01	1.55	23	.01	.00	.01	11.	1.01	13.55	167	.27	.26	.01	608.
1.01	2.00	24	.01	.00	.01	11.	1.01	14.00	168	.27	.26	.01	609.
1.01	2.05	25	.01	.00	.01	11.	1.01	14.05	169	.34	.33	.01	617.
1.01	2.10	26	.01	.00	.01	11.	1.01	14.10	170	.34	.33	.01	640.
1.01	2.15	27	.01	.00	.01	11.	1.01	14.15	171	.34	.33	.01	674.
1.01	2.20	28	.01	.00	.01	11.	1.01	14.20	172	.34	.33	.01	707.
1.01	2.25	29	.01	.00	.01	11.	1.01	14.25	173	.34	.33	.01	731.
1.01	2.30	30	.01	.00	.01	11.	1.01	14.30	174	.34	.33	.01	746.
1.01	2.35	31	.01	.00	.01	10.	1.01	14.35	175	.34	.33	.01	756.
1.01	2.40	32	.01	.00	.01	10.	1.01	14.40	176	.34	.33	.01	762.
1.01	2.45	33	.01	.00	.01	10.	1.01	14.45	177	.34	.33	.01	766.
1.01	2.50	34	.01	.00	.01	10.	1.01	14.50	178	.34	.33	.01	769.
1.01	2.55	35	.01	.00	.01	10.	1.01	14.55	179	.34	.33	.01	771.
1.01	3.00	36	.01	.00	.01	10.	1.01	15.00	180	.34	.33	.01	772.
1.01	3.05	37	.01	.00	.01	10.	1.01	15.05	181	.21	.20	.00	761.
1.01	3.10	38	.01	.00	.01	10.	1.01	15.10	182	.41	.40	.01	738.
1.01	3.15	39	.01	.00	.01	10.	1.01	15.15	183	.41	.40	.01	739.
1.01	3.20	40	.01	.00	.01	10.	1.01	15.20	184	.62	.61	.01	799.
1.01	3.25	41	.01	.00	.01	10.	1.01	15.25	185	.72	.71	.01	927.
1.01	3.30	42	.01	.00	.01	11.	1.01	15.30	186	1.75	1.72	.02	1208.
1.01	3.35	43	.01	.00	.01	11.	1.01	15.35	187	2.88	2.85	.03	1829.
1.01	3.40	44	.01	.00	.01	11.	1.01	15.40	188	1.13	1.12	.01	2691.
1.01	3.45	45	.01	.01	.01	11.	1.01	15.45	189	.72	.71	.01	3229.
1.01	3.50	46	.01	.01	.01	11.	1.01	15.50	190	.62	.61	.00	3174.
1.01	3.55	47	.01	.01	.01	12.	1.01	15.55	191	.41	.41	.00	2729.
1.01	4.00	48	.01	.01	.01	12.	1.01	16.00	192	.41	.41	.00	2178.
1.01	4.05	49	.01	.01	.01	12.	1.01	16.05	193	.32	.31	.00	1748.
1.01	4.10	50	.01	.01	.01	12.	1.01	16.10	194	.32	.31	.00	1419.
1.01	4.15	51	.01	.01	.01	12.	1.01	16.15	195	.32	.31	.00	1175.
1.01	4.20	52	.01	.01	.01	13.	1.01	16.20	196	.32	.31	.00	1010.
1.01	4.25	53	.01	.01	.01	13.	1.01	16.25	197	.32	.31	.00	903.
1.01	4.30	54	.01	.01	.01	13.	1.01	16.30	198	.32	.31	.00	837.
1.01	4.35	55	.01	.01	.01	13.	1.01	16.35	199	.32	.31	.00	797.
1.01	4.40	56	.01	.01	.01	13.	1.01	16.40	200	.32	.31	.00	772.

1.01	4.45	57	.01	.01	.01	14.	1.01	16.45	201	.32	.31	.00	756.
1.01	4.50	58	.01	.01	.01	14.	1.01	16.50	202	.32	.31	.00	745.
1.01	4.55	59	.01	.01	.01	14.	1.01	16.55	203	.32	.31	.00	737.
1.01	5.00	60	.01	.01	.01	14.	1.01	17.00	204	.32	.31	.00	734.
1.01	5.05	61	.01	.01	.01	14.	1.01	17.05	205	.25	.25	.00	727.
1.01	5.10	62	.01	.01	.01	15.	1.01	17.10	206	.25	.25	.00	704.
1.01	5.15	63	.01	.01	.01	15.	1.01	17.15	207	.25	.25	.00	669.
1.01	5.20	64	.01	.01	.01	15.	1.01	17.20	208	.25	.25	.00	637.
1.01	5.25	65	.01	.01	.01	15.	1.01	17.25	209	.25	.25	.00	612.
1.01	5.30	66	.01	.01	.01	15.	1.01	17.30	210	.25	.25	.00	598.
1.01	5.35	67	.01	.01	.01	16.	1.01	17.35	211	.25	.25	.00	590.
1.01	5.40	68	.01	.01	.01	16.	1.01	17.40	212	.25	.25	.00	584.
1.01	5.45	69	.01	.01	.01	16.	1.01	17.45	213	.25	.25	.00	581.
1.01	5.50	70	.01	.01	.01	16.	1.01	17.50	214	.25	.25	.00	579.
1.01	5.55	71	.01	.01	.01	16.	1.01	17.55	215	.25	.25	.00	577.
1.01	6.00	72	.01	.01	.01	16.	1.01	18.00	216	.25	.25	.00	577.
1.01	6.05	73	.07	.03	.03	19.	1.01	18.05	217	.02	.02	.00	555.
1.01	6.10	74	.07	.03	.03	28.	1.01	18.10	218	.02	.02	.00	480.
1.01	6.15	75	.07	.04	.03	42.	1.01	18.15	219	.02	.02	.00	366.
1.01	6.20	76	.07	.04	.03	56.	1.01	18.20	220	.02	.02	.00	306.
1.01	6.25	77	.07	.04	.03	67.	1.01	18.25	221	.02	.02	.00	279.
1.01	6.30	78	.07	.04	.03	75.	1.01	18.30	222	.02	.02	.00	254.
1.01	6.35	79	.07	.04	.03	80.	1.01	18.35	223	.02	.02	.00	232.
1.01	6.40	80	.07	.04	.03	85.	1.01	18.40	224	.02	.02	.00	212.
1.01	6.45	81	.07	.04	.02	88.	1.01	18.45	225	.02	.02	.00	193.
1.01	6.50	82	.07	.04	.02	91.	1.01	18.50	226	.02	.02	.00	176.
1.01	6.55	83	.07	.04	.02	94.	1.01	18.55	227	.02	.02	.00	161.
1.01	7.00	84	.07	.04	.02	96.	1.01	19.00	228	.02	.02	.00	147.
1.01	7.05	85	.07	.04	.02	98.	1.01	19.05	229	.02	.02	.00	134.
1.01	7.10	86	.07	.05	.02	100.	1.01	19.10	230	.02	.02	.00	122.
1.01	7.15	87	.07	.05	.02	102.	1.01	19.15	231	.02	.02	.00	112.
1.01	7.20	88	.07	.05	.02	104.	1.01	19.20	232	.02	.02	.00	102.
1.01	7.25	89	.07	.05	.02	105.	1.01	19.25	233	.02	.02	.00	93.
1.01	7.30	90	.07	.05	.02	107.	1.01	19.30	234	.02	.02	.00	85.
1.01	7.35	91	.07	.05	.02	108.	1.01	19.35	235	.02	.02	.00	77.
1.01	7.40	92	.07	.05	.02	110.	1.01	19.40	236	.02	.02	.00	71.
1.01	7.45	93	.07	.05	.02	111.	1.01	19.45	237	.02	.02	.00	64.
1.01	7.50	94	.07	.05	.02	112.	1.01	19.50	238	.02	.02	.00	59.
1.01	7.55	95	.07	.05	.02	114.	1.01	19.55	239	.02	.02	.00	54.
1.01	8.00	96	.07	.05	.02	115.	1.01	20.00	240	.02	.02	.00	51.
1.01	8.05	97	.07	.05	.02	116.	1.01	20.05	241	.02	.02	.00	51.
1.01	8.10	98	.07	.05	.01	117.	1.01	20.10	242	.02	.02	.00	51.
1.01	8.15	99	.07	.05	.01	118.	1.01	20.15	243	.02	.02	.00	51.
1.01	8.20	100	.07	.05	.01	119.	1.01	20.20	244	.02	.02	.00	51.
1.01	8.25	101	.07	.05	.01	120.	1.01	20.25	245	.02	.02	.00	51.
1.01	8.30	102	.07	.05	.01	121.	1.01	20.30	246	.02	.02	.00	51.
1.01	8.35	103	.07	.05	.01	122.	1.01	20.35	247	.02	.02	.00	51.
1.01	8.40	104	.07	.05	.01	122.	1.01	20.40	248	.02	.02	.00	51.
1.01	8.45	105	.07	.05	.01	123.	1.01	20.45	249	.02	.02	.00	51.
1.01	8.50	106	.07	.05	.01	124.	1.01	20.50	250	.02	.02	.00	51.
1.01	8.55	107	.07	.05	.01	125.	1.01	20.55	251	.02	.02	.00	51.
1.01	9.00	108	.07	.05	.01	126.	1.01	21.00	252	.02	.02	.00	51.
1.01	9.05	109	.07	.06	.01	126.	1.01	21.05	253	.02	.02	.00	51.
1.01	9.10	110	.07	.06	.01	127.	1.01	21.10	254	.02	.02	.00	51.
1.01	9.15	111	.07	.06	.01	128.	1.01	21.15	255	.02	.02	.00	51.
1.01	9.20	112	.07	.06	.01	128.	1.01	21.20	256	.02	.02	.00	51.
1.01	9.25	113	.07	.06	.01	129.	1.01	21.25	257	.02	.02	.00	51.
1.01	9.30	114	.07	.06	.01	129.	1.01	21.30	258	.02	.02	.00	51.
1.01	9.35	115	.07	.06	.01	130.	1.01	21.35	259	.02	.02	.00	51.
1.01	9.40	116	.07	.06	.01	130.	1.01	21.40	260	.02	.02	.00	51.

1.01	9.45	117	.07	.06	.01	131.	1.01	21.45	261	.02	.02	.00	51.
1.01	9.50	118	.07	.06	.01	132.	1.01	21.50	262	.02	.02	.00	51.
1.01	9.55	119	.07	.06	.01	132.	1.01	21.55	263	.02	.02	.00	51.
1.01	10.00	120	.07	.06	.01	132.	1.01	22.00	264	.02	.02	.00	51.
1.01	10.05	121	.07	.06	.01	133.	1.01	22.05	265	.02	.02	.00	51.
1.01	10.10	122	.07	.06	.01	133.	1.01	22.10	266	.02	.02	.00	51.
1.01	10.15	123	.07	.06	.01	134.	1.01	22.15	267	.02	.02	.00	51.
1.01	10.20	124	.07	.06	.01	134.	1.01	22.20	268	.02	.02	.00	51.
1.01	10.25	125	.07	.06	.01	135.	1.01	22.25	269	.02	.02	.00	51.
1.01	10.30	126	.07	.06	.01	135.	1.01	22.30	270	.02	.02	.00	51.
1.01	10.35	127	.07	.06	.01	135.	1.01	22.35	271	.02	.02	.00	51.
1.01	10.40	128	.07	.06	.01	136.	1.01	22.40	272	.02	.02	.00	51.
1.01	10.45	129	.07	.06	.01	136.	1.01	22.45	273	.02	.02	.00	51.
1.01	10.50	130	.07	.06	.01	137.	1.01	22.50	274	.02	.02	.00	51.
1.01	10.55	131	.07	.06	.01	137.	1.01	22.55	275	.02	.02	.00	51.
1.01	11.00	132	.07	.06	.01	137.	1.01	23.00	276	.02	.02	.00	51.
1.01	11.05	133	.07	.06	.01	138.	1.01	23.05	277	.02	.02	.00	51.
1.01	11.10	134	.07	.06	.01	138.	1.01	23.10	278	.02	.02	.00	51.
1.01	11.15	135	.07	.06	.01	138.	1.01	23.15	279	.02	.02	.00	51.
1.01	11.20	136	.07	.06	.01	138.	1.01	23.20	280	.02	.02	.00	51.
1.01	11.25	137	.07	.06	.01	139.	1.01	23.25	281	.02	.02	.00	51.
1.01	11.30	138	.07	.06	.01	139.	1.01	23.30	282	.02	.02	.00	51.
1.01	11.35	139	.07	.06	.01	139.	1.01	23.35	283	.02	.02	.00	51.
1.01	11.40	140	.07	.06	.01	140.	1.01	23.40	284	.02	.02	.00	51.
1.01	11.45	141	.07	.06	.01	140.	1.01	23.45	285	.02	.02	.00	51.
1.01	11.50	142	.07	.06	.01	140.	1.01	23.50	286	.02	.02	.00	51.
1.01	11.55	143	.07	.06	.01	140.	1.01	23.55	287	.02	.02	.00	51.
1.01	12.00	144	.07	.06	.01	141.	1.02	0.00	288	.02	.02	.00	51.
									SUM	34.45	32.23	2.22	76473.
										(875.)	(819.)	(56.)	(2165.47)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3229.	849.	265.	265.	76457.
CMS	91.	24.	8.	8.	2165.
INCHES		26.19	32.75	32.75	32.75
MM		665.20	831.92	831.92	831.92
AC-FT		421.	527.	527.	527.
THOUS CU M		519.	650.	650.	650.

HYDROGRAPH AT STALOC FL FOR PLAN 1, RTIO 1

2.	2.	4.	5.	5.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	7.	7.
7.	7.	7.	7.	7.	7.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	9.	9.	9.	9.
9.	9.	10.	15.	23.	31.	37.	41.	44.	46.
[illegible]	50.	52.	53.	54.	55.	56.	57.	58.	59.
[illegible]	60.	61.	62.	62.	63.	64.	64.	65.	65.
[illegible]	66.	67.	67.	68.	68.	69.	69.	69.	70.
70.	70.	71.	71.	71.	72.	72.	72.	73.	73.
73.	73.	74.	74.	74.	74.	75.	75.	75.	75.
75.	75.	76.	76.	76.	76.	76.	76.	77.	77.
77.	77.	77.	77.	85.	112.	153.	193.	222.	240.
252.	259.	264.	267.	270.	271.	275.	284.	297.	309.
[illegible]	324.	326.	330.	332.	333.	334.	335.	339.	352.
371.	389.	402.	410.	416.	419.	421.	423.	424.	425.
414.	406.	407.	439.	510.	664.	1006.	1480.	1776.	1745.
1501.	1198.	961.	780.	646.	555.	496.	461.	438.	425.
[illegible]	410.	406.	404.	400.	387.	368.	350.	337.	329.
[illegible]	321.	319.	318.	318.	317.	305.	264.	201.	168.
153.	140.	128.	117.	106.	97.	89.	81.	74.	67.
61.	56.	51.	47.	43.	39.	35.	32.	29.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1776.	467.	146.	146.	42051.
CMS	50.	13.	4.	4.	1191.
INCHES		14.40	18.01	18.01	18.01
MM		365.86	457.55	457.55	457.55
AC-FT		232.	290.	290.	290.
THOUS CU M		286.	357.	357.	357.

HYDROGRAPH AT STAEM SPW FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	1.	1.	1.	1.	1.	3.	4.
6.	12.	17.	27.	36.	45.	54.	64.	68.	70.
72.	75.	77.	78.	79.	80.	81.	81.	76.	75.
74.	73.	70.	66.	64.	63.	62.	60.	58.	56.
54.	52.	50.	45.	41.	38.	36.	31.	27.	24.
21.	19.	17.	15.	12.	11.	10.	8.	7.	6.
5.	4.	3.	3.	3.	2.	1.	1.	1.	1.
1.	1.	1.	1.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	81.	33.	8.	8.	2383.
CMS	2.	1.	0.	0.	67.
INCHES		1.02	1.02	1.02	1.02
MM		25.93	25.93	25.93	25.93
AC-FT		16.	16.	16.	16.
THOUS CU M		20.	20.	20.	20.

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINED FLOW FROM LOCAL PMF & OUTFLOW FROM EMERGENCY SPILLWAY UPSTREAM

	ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
	COMBND	2	0	0	0	0	1	0	0

SUM OF 2 HYDROGRAPHS AT COMBND PLAN 1 RTIO 1

2.	2.	4.	5.	5.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	7.	7.
7.	7.	7.	7.	7.	7.	8.	8.	8.	8.
8.	8.	8.	8.	8.	8.	9.	9.	9.	9.
9.	9.	10.	15.	23.	31.	37.	41.	44.	46.
48.	50.	52.	53.	54.	55.	56.	57.	58.	59.
60.	60.	61.	62.	62.	63.	64.	64.	65.	65.
66.	66.	67.	67.	68.	68.	69.	69.	69.	70.
70.	70.	71.	71.	71.	72.	72.	72.	73.	73.
73.	73.	74.	74.	74.	74.	75.	75.	75.	75.
75.	75.	76.	76.	76.	76.	76.	76.	77.	77.
77.	77.	77.	77.	85.	112.	153.	193.	222.	240.
252.	259.	264.	267.	270.	271.	275.	284.	297.	309.
318.	324.	328.	330.	332.	333.	334.	335.	339.	352.
371.	389.	402.	410.	416.	419.	421.	423.	424.	425.
418.	406.	407.	440.	511.	665.	1007.	1481.	1779.	1750.
1507.	1210.	978.	807.	682.	600.	550.	525.	506.	495.
488.	485.	483.	482.	479.	467.	449.	431.	413.	404.
396.	394.	389.	384.	382.	380.	367.	324.	259.	224.
207.	192.	178.	162.	147.	135.	125.	112.	101.	91.
82.	75.	68.	62.	55.	50.	45.	40.	36.	34.
33.	32.	31.	31.	31.	30.	29.	29.	29.	29.
29.	29.	29.	29.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.	28.	28.
28.	28.	28.	28.	28.	28.	28.	28.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1779.	492.	154.	154.	44434.
CMS	50.	14.	4.	4.	1258.
INCHES		7.59	9.52	9.52	9.52
MM		192.78	241.74	241.74	241.74
AC-FT		244.	306.	306.	306.
THOUS CU M		301.	377.	377.	377.

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**********          **********          **********          **********          **********

                                   HYDROGRAPH ROUTING

          ROUTING OF COMBINED PMF THROUGH RESERVOIR

                     ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                    L LAKE       1       0       0       1       1       1       0       0
                                           ROUTING DATA
               QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                 0.0   0.000    0.00       1       1       0       0               0

                     NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                         1       0       0   0.000   0.000   0.000   -833.      -1

STAGE        830.00    831.00    831.50    832.00    832.50    833.00    833.50    834.00    834.50    835.00
             835.70    836.00    836.50    837.00    837.50    838.00    839.00    840.00    841.00

FLOW           0.00      8.00     28.00     53.00     83.00     94.00    120.00    165.00    225.00    310.00
             470.00    730.00   1650.00   3520.00   6320.00   9320.00  16530.00  26030.00  36730.00

SURFACE AREA=      0.       16.       38.       40.       42.       44.       46.       49.       53.       58.

CAPACITY=          0.      109.      453.      492.      533.      563.      622.      669.      771.      882.

ELEVATION=       800.      820.      833.      834.      835.      836.      837.      833.      840.      842.

                  CREL   SPWID    COQW    EXPW   ELEVL    COOL   CAREA    EXPL
                 833.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                         DAM DATA
                                 TOPEL    COQD    EXPD  DAMWID
                                 839.7     0.0     0.0      0.
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .55
HYDROGRAPH AT	LOC FL	.30 (.78)	1	1776. (50.29)(
HYDROGRAPH AT	EM SPW	.30 (.78)	1	81. (2.29)(
2 COMBINED	COMBND	.60 (1.56)	1	1779. (50.37)(
ROUTED TO	L LAKE	.60 (1.56)	1	432. (12.24)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	833.00	833.00	835.70
STORAGE	453.	453.	563.
OUTFLOW	94.	94.	479.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.55	835.54	0.00	556.	432.	0.00	17.33	0.00

```
A1          ANCHUTZ TAILING DAM ID NO 31082
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3          60 % PMF ROUTED THROUGH RESERVOIR
B     288                 5
B1      5
J       1         1         1
J1   0.60
K       0   LOC FI                          1         1         1
K1  60 % PMF INFLOW FROM LOCAL DRAINAGE AREA
M       1         2   0.3016                          1                             1
P       0      26.5       102       120       130
T                                                               -1       -78                0.3
W2             0.24
X     -10       -.1       2.5
K       0   EM SPW                                              1
K1  60 % PMF OUTFLOW FROM EMERGENCY SPILLWAY OF UPSTREAM DAM # 31080
M      -1         2   0.3016                          1
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
N
```

```
N    1.67     1.67     1.67     1.67     1.67     1.67     5.00     6.67     8.33    13.33
N   20.00    35.00    51.67    68.33    88.33    100.0   116.67   133.33   146.67   150.00
N  153.33   156.67   160.00   163.33   160.00   156.67   155.00   153.33   153.33   153.33
N  150.00   146.67   140.00   136.33   136.67   135.00   133.33   125.00   116.67   113.33
N  110.00   106.67   103.33    96.67    90.00    83.33    25.00    68.33    63.33    60.00
N   51.67    45.00    40.00    55.00    28.33    25.00    20.00    18.33    16.67    13.33
N   11.67    10.00     8.33     6.67     6.67     5.00     5.00     5.00     3.33     1.67
N    1.67     1.67     1.67     1.67     1.67     1.67       0.       0.       0.       0.
N
N
N
K       2  COMBND                                                  1
K1 COMBINED FLOW FROM LOCAL PMF & OUTFLOW FROM EMERGENCY SPILLWAY UPSTREAM
K       1  L LAKE                                 1        1        1
K1 ROUTING OF COMBINED PMF THROUGH RESERVOIR
Y                                        1        1
Y1      1                                                -833.      -1
Y4  830.6    831.0    831.5    832.0    832.5    833.0    833.5    834.0    834.5    835.0
Y4  835.7    836.0    836.5    837.0    837.5    838.0    839.0    840.0    841.0
Y5    0.0       8.      28.      53.      83.      94.     120.     165.     225.     310.
Y5   470.     730.    1650.    3520.    6320.    9320.   16530.   26030.   36730.
$A     0.     16.4     38.0     40.0     42.0     43.5     46.4     48.7     53.3     58.0
$E   830.     820.     833.     834.     835.    835.7     837.     838.     840.     842.
$$  833.0
$D  835.7
K      99
A
A
A
A
A
```

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*************************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
LAST MODIFICATION 26 FEB 79
*************************************

RUN DATE* 79/08/21.
    TIME* 14.10.15.

                    ANCHUTZ TAILING DAM ID NO 31082
                    HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
                    60 % PMF ROUTED THROUGH RESERVOIR

                                       JOB SPECIFICATION
        NQ    NHR   NMIN   IDAY    IHR   IMIN  METRC   IPLT   IPRT  NSTAN
       288      0      5      0      0      0      0      0      0      0
                           JOPER    NWT  LROPT  TRACE
                              5      0      0      0

                               MULTI-PLAN ANALYSES TO BE PERFORMED
                                 NPLAN= 1 NRTIO= 1 LRTIO= 1
   RTIOS=    .60

  **********     **********     **********     **********     **********

                                  SUB-AREA RUNOFF COMPUTATION

     60 % PMF INFLOW FROM LOCAL DRAINAGE AREA

                    ISTAQ  ICOMP  IECON  ITAPE   JPLT   JPRT  INAME ISTAGE  IAUTO
                    LOC FL     0      0      0      1      1      1      0      0

                                      HYDROGRAPH DATA
     IHYDG   IUHG   TAREA   SNAP  TRSDA  TRSPC  RATIO  ISNOW  ISAME  LOCAL
         1      2     .30   0.00    .30   1.00  0.000      0      1      0

                                        PRECIP DATA
                 SPFE     PMS      R6     R12     R24     R48     R72     R96
                 0.00   26.50  102.00  120.00  130.00    0.00    0.00    0.00

                                         LOSS DATA
    LROPT  STRKR  DLTKR  RTIOL  ERAIN  STRKS  RTIOK  STRTL  CNSTL  ALSMX  RTIMP
              .00   0.00   1.00   0.10   0.00   1.00  -1.00 -78.00   0.00    .30

     CURVE NO = -78.00  WETNESS =   -1.00  EFFECT CN =   78.00

                                   UNIT HYDROGRAPH DATA
                               TC=  0.00    LAG=    .24

                                      RECESSION DATA
                          STRTQ=  -10.00    QRCSN=   -.10    RTIOR= 2.50

     UNIT HYDROGRAPH 16 END OF PERIOD ORDINATES, TC=   0.00 HOURS, LAG=    .24  VOL= 1.00
    99.     335.     507.     445.     362.     210.     131.      81.      50.      31.
    19.      12.       7.       5.       3.       1.
```

HYDROGRAPH AT STALOC FL FOR PLAN 1, RTIO 1

2.	3.	4.	5.	6.	6.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	7.	7.	7.	7.	7.	7.	7.
7.	8.	8.	8.	8.	8.	8.	8.	8.	9.
9.	9.	9.	9.	9.	9.	9.	9.	10.	10.
10.	10.	11.	17.	25.	33.	40.	45.	48.	51.
53.	55.	56.	58.	59.	60.	61.	62.	63.	64.
65.	66.	67.	67.	68.	69.	69.	70.	71.	71.
72.	72.	73.	73.	74.	74.	75.	75.	76.	76.
77.	77.	77.	78.	78.	78.	79.	79.	79.	79.
80.	80.	80.	81.	81.	81.	81.	82.	82.	82.
82.	82.	83.	83.	83.	83.	83.	83.	84.	84.
84.	84.	84.	84.	93.	122.	137.	210.	243.	262.
275.	283.	288.	292.	294.	296.	300.	310.	324.	337.
347.	353.	358.	360.	362.	364.	365.	366.	370.	384.
404.	424.	439.	448.	453.	457.	459.	461.	462.	463.
456.	443.	444.	479.	556.	725.	1098.	1614.	1937.	1904.
1638.	1307.	1049.	851.	705.	606.	542.	502.	478.	463.
454.	447.	442.	441.	436.	422.	402.	382.	367.	359.
354.	350.	348.	347.	346.	340.	333.	288.	219.	183.
157.	153.	139.	127.	116.	106.	97.	88.	80.	73.
67.	61.	56.	51.	46.	42.	39.	35.	32.	31.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1937.	509.	159.	159.	45874.
CMS	55.	14.	5.	5.	1299.
INCHES		15.71	19.65	19.65	19.65
MM		399.12	499.15	499.15	499.15
AC-FT		255.	316.	316.	316.
THOUS CU M		312.	390.	390.	390.

HYDROGRAPH AT STAEM SPW FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	1.	1.	1.	1.	1.	3.	4.	5.	8.
12.	21.	31.	41.	53.	60.	70.	80.	88.	90.
92.	94.	96.	98.	96.	94.	93.	92.	92.	92.
97.	88.	84.	83.	82.	81.	80.	75.	70.	68.
66.	64.	62.	58.	54.	50.	15.	41.	36.	36.
31.	27.	24.	21.	17.	15.	12.	11.	10.	8.
7.	6.	5.	4.	4.	3.	3.	3.	2.	1.
1.	1.	1.	1.	1.	1.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	98.	42.	10.	10.	3016.
CMS	3.	1.	0.	0.	85.
INCHES		1.29	1.29	1.29	1.29
MM		32.77	32.82	32.82	32.82
AC-FT		21.	21.	21.	21.
THOUS CU M		26.	26.	26.	26.

**********   **********   **********   ***** ***   **********

COMBINE HYDROGRAPHS

COMBINED FLOW FROM LOCAL PMF & OUTFLOW FROM EMERGENCY SPILLWAY UPSTREAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
COMBND	2	0	0	0	0	1	0	0

SUM OF 2 HYDROGRAPHS AT COMBND PLAN 1 RTIO 1

2.	3.	4.	5.	6.	6.	7.	7.	7.	7.
7.	7.	7.	7.	7.	7.	7.	7.	7.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	6.	6.	6.	6.	6.	6.	6.
6.	6.	6.	7.	7.	7.	7.	7.	7.	7.
7.	8.	8.	8.	8.	8.	8.	8.	8.	9.
9.	9.	9.	9.	9.	9.	9.	9.	10.	10.
10.	10.	11.	17.	25.	33.	40.	45.	48.	51.
53.	55.	56.	58.	59.	60.	61.	62.	63.	64.
65.	66.	67.	67.	68.	69.	69.	70.	71.	71.
72.	72.	73.	73.	74.	74.	75.	75.	76.	76.
77.	77.	77.	78.	78.	78.	79.	79.	79.	79.
80.	80.	80.	81.	81.	81.	81.	82.	82.	82.
82.	82.	83.	83.	83.	83.	83.	83.	84.	84.
85.	88.	84.	84.	93.	122.	167.	210.	243.	262.
275.	283.	288.	292.	294.	296.	300.	310.	324.	337.
347.	353.	358.	360.	362.	364.	365.	366.	370.	384.
404.	424.	439.	448.	453.	457.	459.	461.	462.	463.
457.	444.	445.	480.	557.	726.	1101.	1618.	1942.	1912.
1050.	1328.	1080.	892.	758.	666.	612.	582.	566.	553.
546.	541.	538.	539.	532.	516.	495.	474.	459.	451.
444.	438.	432.	430.	429.	427.	413.	363.	289.	251.
255.	217.	201.	185.	170.	156.	112.	129.	118.	109.
98.	88.	80.	72.	63.	57.	51.	46.	42.	39.
38.	37.	36.	35.	35.	34.	34.	34.	33.	32.
32.	32.	32.	32.	32.	32.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.	31.	31.
31.	31.	31.	31.	31.	31.	31.	31.		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1942.	541.	170.	170.	48890.
CMS	55.	15.	5.	5.	1384.
INCHES		8.35	10.47	10.47	10.47
MM		212.04	265.98	265.98	265.98
AC-FT		268.	337.	337.	337.
THOUS CU M		331.	415.	415.	415.

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**********          **********          **********          **********          **********

                                   HYDROGRAPH ROUTING

          ROUTING OF COMBINED PMF THROUGH RESERVOIR

                    ISTAQ   ICOMP   IECON   ITAPE   JPLT    JPRT   INAME  ISTAGE   IAUTO
                     LAKE       1       0       0      1       1       1       0       0
                                            ROUTING DATA
             QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP                 LSTR
               0.0   0.000    0.00       1       1       0       0                    0

                    NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                        1       0       0   0.000   0.000   0.000   -833.      -1

STAGE       830.00      831.00      831.50      832.00      832.50      833.00      833.50      834.00      834.50      835.00
            835.70      836.00      836.50      837.00      837.50      838.00      839.00      840.00      841.00

FLOW          0.00        8.00       28.00       53.00       83.00       94.00      120.00      165.00      225.00      310.00
            470.00      730.00     1650.00     3520.00     6320.00     9320.00    16530.00    26030.00    36730.00

SURFACE AREA=      0.        16.        38.        40.        42.        44.        46.        49.        53.        58.

    CAPACITY=      0.       109.       453.       492.       533.       563.       622.       669.       771.       882.

   ELEVATION=    800.       820.       833.       834.       835.       836.       837.       838.       840.       842.

                 CREL   SPWID    COQW    EXPW   ELEVL    COQL   CAREA    EXPL
                833.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

                                          DAM DATA
                                  TOPEL    COQD    EXPD  DAMWID
                                  835.7     0.0     0.0      0.
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .60
HYDROGRAPH AT	LOC FL	.30	1	1937.
	(	.78)	(	54.86)(
HYDROGRAPH AT	EM SPW	.30	1	98.
	(	.78)	(	2.77)(
2 COMBINED	COMBND	.60	1	1942.
	(	1.56)	(	55.00)(
ROUTED TO	L LAKE	.60	1	529.
	(	1.56)	(	14.97)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	833.00	833.00	835.70
STORAGE	453.	453.	563.
OUTFLOW	94.	94.	470.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.60	835.77	.07	566.	529.	1.58	17.08	0.00

```
A1          ANSCHUTZ DAM   ID NO 31082
A2          HEC-1  PHASE 1  DAM SAFETY INVESTIGATION
A3          PMF INFLOW TO CANAL - DRAINAGE AREA ABOVE SMALL PONDS
B     288              5                                   0         2
B1      3
K       0  IFL CNL                                    1        1
K1   PMF INFLOW TO SPILLWAY CHANNEL OF DAM ID NO 31082 FROM DA ABOVE
M       1         2  0.0551                            1.
P       0      26.5      102      120      130
T                                                              -1       -72
W2             0.20
X     -10       -.1      2.5
K      99
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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION       JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE* 79/07/12.
     TIME* 15.19.22.

                    ANSCHUTZ DAM  ID NO 31082
                    HEC-1  PHASE 1  DAM SAFETY INVESTIGATION
                    PMF INFLOW TO CANAL - DRAINAGE AREA ABOVE SMALL PONDS

                                    JOB SPECIFICATION
        NQ     NHR     NMIN    IDAY     IHR    IMIN   METRC    IPLT    IPRT   NSTAN
       255       0        5       0       0       0       0       0       2       0
                                JOPER     NWT   LROPT   TRACE
                                    3       0       0       0


   **********          **********          **********          **********          **********

                              SUB-AREA RUNOFF COMPUTATION

        PMF INFLOW TO SPILLWAY CHANNEL OF DAM ID NO 31082 FROM DA ABOVE

                    ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                    FL CNL      0       0       0       0       1       1       0       0

                                    HYDROGRAPH DATA
        IHYDG   IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
            1      2     .05    0.00     .05    1.00   0.000       0       0       0

                                      PRECIP DATA
                    SPFE     PMS      R6     R12     R24     R48     R72     R96
                    0.00   26.50  102.00  120.00  130.00    0.00    0.00    0.00

                                       LOSS DATA
     LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
         0    0.00    0.00    1.00    0.00    0.00    1.00   -1.00  -72.00    0.00    0.00

        CURVE NO =  -72.00  WETNESS =   -1.00  EFFECT CN =   72.00

                                   UNIT HYDROGRAPH DATA
                                 TC=   0.00    LAG=    .20

                                     RECESSION DATA
                         STRTQ=  -10.00    QRCSN=    -.10    RTIOR= 2.50

        UNIT HYDROGRAPH 14 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=    .20  VOL= 1.00
     26.      65.     100.      65.      47.      27.      15.       9.       5.       3.
      2.       1.       1.       0.

       0                                END-OF-PERIOD FLOW
   MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q       MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS   COMP Q

    1.01    .05       1    .01   0.00    .01       0.        1.01  12.05     145    .23    .18    .04      25.
```

1.01	.10	2	.01	0.00	.01	0.	1.01	12.10	146	.23	.19	.04	36.
1.01	.15	3	.01	0.00	.01	0.	1.01	12.15	147	.23	.19	.04	50.
1.01	.20	4	.01	0.00	.01	0.	1.01	12.20	148	.23	.19	.04	62.
1.01	.25	5	.01	0.00	.01	0.	1.01	12.25	149	.23	.19	.03	69.
1.01	.30	6	.01	0.00	.01	0.	1.01	12.30	150	.23	.19	.03	73.
1.01	.35	7	.01	0.00	.01	0.	1.01	12.35	151	.23	.19	.03	75.
1.01	.40	8	.01	0.00	.01	0.	1.01	12.40	152	.23	.20	.03	77.
1.01	.45	9	.01	0.00	.01	0.	1.01	12.45	153	.23	.20	.03	78.
1.01	.50	10	.01	0.00	.01	0.	1.01	12.50	154	.23	.20	.03	79.
1.01	.55	11	.01	0.00	.01	0.	1.01	12.55	155	.23	.20	.03	80.
1.01	1.00	12	.01	0.00	.01	0.	1.01	13.00	156	.23	.20	.03	81.
1.01	1.05	13	.01	0.00	.01	0.	1.01	13.05	157	.27	.24	.03	82.
1.01	1.10	14	.01	0.00	.01	0.	1.01	13.10	158	.27	.24	.03	86.
1.01	1.15	15	.01	0.00	.01	0.	1.01	13.15	159	.27	.24	.03	91.
1.01	1.20	16	.01	0.00	.01	0.	1.01	13.20	160	.27	.24	.03	95.
1.01	1.25	17	.01	0.00	.01	0.	1.01	13.25	161	.27	.25	.02	97.
1.01	1.30	18	.01	0.00	.01	0.	1.01	13.30	162	.27	.25	.02	99.
1.01	1.35	19	.01	0.00	.01	0.	1.01	13.35	163	.27	.25	.02	100.
1.01	1.40	20	.01	0.00	.01	0.	1.01	13.40	164	.27	.25	.02	101.
1.01	1.45	21	.01	0.00	.01	0.	1.01	13.45	165	.27	.25	.02	101.
1.01	1.50	22	.01	0.00	.01	0.	1.01	13.50	166	.27	.25	.02	102.
1.01	1.55	23	.01	0.00	.01	0.	1.01	13.55	167	.27	.25	.02	102.
1.01	2.00	24	.01	0.00	.01	0.	1.01	14.00	168	.27	.25	.02	102.
1.01	2.05	25	.01	0.00	.01	0.	1.01	14.05	169	.34	.32	.02	104.
1.01	2.10	26	.01	0.00	.01	0.	1.01	14.10	170	.34	.32	.02	110.
1.01	2.15	27	.01	0.00	.01	0.	1.01	14.15	171	.34	.32	.02	117.
1.01	2.20	28	.01	0.00	.01	0.	1.01	14.20	172	.34	.32	.02	123.
1.01	2.25	29	.01	0.00	.01	0.	1.01	14.25	173	.34	.32	.02	126.
1.01	2.30	30	.01	0.00	.01	0.	1.01	14.30	174	.34	.32	.02	128.
1.01	2.35	31	.01	0.00	.01	0.	1.01	14.35	175	.34	.32	.02	130.
1.01	2.40	32	.01	0.00	.01	0.	1.01	14.40	176	.34	.32	.02	130.
1.01	2.45	33	.01	0.00	.01	0.	1.01	14.45	177	.34	.32	.02	131.
1.01	2.50	34	.01	0.00	.01	0.	1.01	14.50	178	.34	.32	.02	131.
1.01	2.55	35	.01	0.00	.01	0.	1.01	14.55	179	.34	.32	.02	132.
1.01	3.00	36	.01	0.00	.01	0.	1.01	15.00	180	.34	.32	.01	132.
1.01	3.05	37	.01	0.00	.01	0.	1.01	15.05	181	.21	.20	.01	129.
1.01	3.10	38	.01	0.00	.01	0.	1.01	15.10	182	.41	.39	.02	124.
1.01	3.15	39	.01	0.00	.01	0.	1.01	15.15	183	.41	.39	.02	127.
1.01	3.20	40	.01	0.00	.01	0.	1.01	15.20	184	.62	.59	.02	143.
1.01	3.25	41	.01	0.00	.01	0.	1.01	15.25	185	.72	.69	.02	173.
1.01	3.30	42	.01	0.00	.01	0.	1.01	15.30	186	1.75	1.69	.05	234.
1.01	3.35	43	.01	0.00	.01	0.	1.01	15.35	187	2.88	2.80	.07	379.
1.01	3.40	44	.01	0.00	.01	0.	1.01	15.40	188	1.13	1.11	.02	555.
1.01	3.45	45	.01	0.00	.01	0.	1.01	15.45	189	.72	.70	.01	613.
1.01	3.50	46	.01	0.00	.01	0.	1.01	15.50	190	.62	.60	.01	544.
1.01	3.55	47	.01	0.00	.01	0.	1.01	15.55	191	.41	.40	.01	428.
1.01	4.00	48	.01	0.00	.01	0.	1.01	16.00	192	.41	.40	.01	333.
1.01	4.05	49	.01	0.00	.01	0.	1.01	16.05	193	.32	.31	.01	264.
1.01	4.10	50	.01	0.00	.01	0.	1.01	16.10	194	.32	.31	.01	212.
1.01	4.15	51	.01	0.00	.01	0.	1.01	16.15	195	.32	.31	.01	178.
1.01	4.20	52	.01	0.00	.01	0.	1.01	16.20	196	.32	.31	.01	156.
1.01	4.25	53	.01	0.00	.01	0.	1.01	16.25	197	.32	.31	.01	144.
1.01	4.30	54	.01	0.00	.01	0.	1.01	16.30	198	.32	.31	.00	137.
1.01	4.35	55	.01	0.00	.01	0.	1.01	16.35	199	.32	.31	.00	133.
1.01	4.40	56	.01	0.00	.01	0.	1.01	16.40	200	.32	.31	.00	130.
1.01	4.45	57	.01	0.00	.01	0.	1.01	16.45	201	.32	.31	.00	129.
1.01	4.50	58	.01	0.00	.01	0.	1.01	16.50	202	.32	.31	.00	128.
1.01	4.55	59	.01	0.00	.01	0.	1.01	16.55	203	.32	.31	.00	128.
1.01	5.00	60	.01	0.00	.01	0.	1.01	17.00	204	.32	.31	.00	126.
1.01	5.05	61	.01	0.00	.01	0.	1.01	17.05	205	.25	.24	.00	126.

1.01	5.10	62	.01	.00	.01	0.	1.01	17.10	206	.25	.24	.00	120.
1.01	5.15	63	.01	.00	.01	0.	1.01	17.15	207	.25	.24	.00	113.
1.01	5.20	64	.01	.00	.01	0.	1.01	17.20	208	.25	.24	.00	108.
1.01	5.25	65	.01	.00	.01	0.	1.01	17.25	209	.25	.24	.00	105.
1.01	5.30	66	.01	.00	.01	0.	1.01	17.30	210	.25	.24	.00	103.
1.01	5.35	67	.01	.00	.01	0.	1.01	17.35	211	.25	.24	.00	102.
1.01	5.40	68	.01	.00	.01	1.	1.01	17.40	212	.25	.24	.00	101.
1.01	5.45	69	.01	.00	.01	1.	1.01	17.45	213	.25	.24	.00	101.
1.01	5.50	70	.01	.00	.01	1.	1.01	17.50	214	.25	.24	.00	101.
1.01	5.55	71	.01	.00	.01	1.	1.01	17.55	215	.25	.24	.00	101.
1.01	6.00	72	.01	.00	.01	1.	1.01	18.00	216	.25	.24	.00	101.
1.01	6.05	73	.07	.01	.06	1.	1.01	18.05	217	.02	.02	.00	95.
1.01	6.10	74	.07	.01	.05	2.	1.01	18.10	218	.02	.02	.00	76.
1.01	6.15	75	.07	.01	.05	3.	1.01	18.15	219	.02	.02	.00	59.
1.01	6.20	76	.07	.01	.05	4.	1.01	18.20	220	.02	.02	.00	54.
1.01	6.25	77	.07	.02	.05	5.	1.01	18.25	221	.02	.02	.00	49.
1.01	6.30	78	.07	.02	.05	5.	1.01	18.30	222	.02	.02	.00	45.
1.01	6.35	79	.07	.02	.05	6.	1.01	18.35	223	.02	.02	.00	41.
1.01	6.40	80	.07	.02	.05	7.	1.01	18.40	224	.02	.02	.00	37.
1.01	6.45	81	.07	.02	.04	7.	1.01	18.45	225	.02	.02	.00	34.
1.01	6.50	82	.07	.02	.04	8.	1.01	18.50	226	.02	.02	.00	31.
1.01	6.55	83	.07	.02	.04	8.	1.01	18.55	227	.02	.02	.00	28.
1.01	7.00	84	.07	.03	.04	9.	1.01	19.00	228	.02	.02	.00	26.
1.01	7.05	85	.07	.03	.04	9.	1.01	19.05	229	.02	.02	.00	24.
1.01	7.10	86	.07	.03	.04	10.	1.01	19.10	230	.02	.02	.00	22.
1.01	7.15	87	.07	.03	.04	10.	1.01	19.15	231	.02	.02	.00	20.
1.01	7.20	88	.07	.03	.04	11.	1.01	19.20	232	.02	.02	.00	18.
1.01	7.25	89	.07	.03	.04	11.	1.01	19.25	233	.02	.02	.00	16.
1.01	7.30	90	.07	.03	.04	12.	1.01	19.30	234	.02	.02	.00	15.
1.01	7.35	91	.07	.03	.03	12.	1.01	19.35	235	.02	.02	.00	14.
1.01	7.40	92	.07	.03	.03	12.	1.01	19.40	236	.02	.02	.00	12.
1.01	7.45	93	.07	.03	.03	13.	1.01	19.45	237	.02	.02	.00	11.
1.01	7.50	94	.07	.03	.03	13.	1.01	19.50	238	.02	.02	.00	10.
1.01	7.55	95	.07	.03	.03	13.	1.01	19.55	239	.02	.02	.00	9.
1.01	8.00	96	.07	.04	.03	14.	1.01	20.00	240	.02	.02	.00	9.
1.01	8.05	97	.07	.04	.03	14.	1.01	20.05	241	.02	.02	.00	9.
1.01	8.10	98	.07	.04	.03	14.	1.01	20.10	242	.02	.02	.00	9.
1.01	8.15	99	.07	.04	.03	15.	1.01	20.15	243	.02	.02	.00	9.
1.01	8.20	100	.07	.04	.03	15.	1.01	20.20	244	.02	.02	.00	9.
1.01	8.25	101	.07	.04	.03	15.	1.01	20.25	245	.02	.02	.00	9.
1.01	8.30	102	.07	.04	.03	16.	1.01	20.30	246	.02	.02	.00	9.
1.01	8.35	103		.04	.03	16.	1.01	20.35	247	.02	.02	.00	9.
1.01	8.40	104		.04	.03	16.	1.01	20.40	248	.02	.02	.00	9.
1.01	8.45	105		.04	.03	16.	1.01	20.45	249	.02	.02	.00	9.
1.01	8.50	106	.07	.04	.02	17.	1.01	20.50	250	.02	.02	.00	9.
1.01	8.55	107	.07	.04	.02	17.	1.01	20.55	251	.02	.02	.00	9.
1.01	9.00	108	.07	.04	.02	17.	1.01	21.00	252	.02	.02	.00	9.
1.01	9.05	109	.07	.04	.02	17.	1.01	21.05	253	.02	.02	.00	9.
1.01	9.10	110	.07	.04	.02	17.	1.01	21.10	254	.02	.02	.00	9.
1.01	9.15	111	.07	.04	.02	18.	1.01	21.15	255	.02	.02	.00	9.
1.01	9.20	112	.07	.04	.02	18.	1.01	21.20	256	.02	.02	.00	9.
1.01	9.25	113	.07	.04	.02	18.	1.01	21.25	257	.02	.02	.00	9.
1.01	9.30	114	.07	.05	.02	18.	1.01	21.30	258	.02	.02	.00	9.
1.01	9.35	115	.07	.05	.02	18.	1.01	21.35	259	.02	.02	.00	9.
1.01	9.40	116	.07	.05	.02	18.	1.01	21.40	260	.02	.02	.00	9.
1.01	9.45	117	.07	.05	.02	19.	1.01	21.45	261	.02	.02	.00	9.
1.01	9.50	118	.07	.05	.02	19.	1.01	21.50	262	.02	.02	.00	9.
1.01	9.55	119	.07	.05	.02	19.	1.01	21.55	263	.02	.02	.00	9.
1.01	10.00	120	.07	.05	.02	19.	1.01	22.00	264	.02	.02	.00	9.
1.01	10.05	121	.07	.05	.02	19.	1.01	22.05	265	.02	.02	.00	9.

1.01	10.10	122	.07	.05	.02	19.	1.01	22.10	266	.02	.02	.00	9.
1.01	10.15	123	.07	.05	.02	20.	1.01	22.15	267	.02	.02	.00	9.
1.01	10.20	124	.07	.05	.02	20.	1.01	22.20	268	.02	.02	.00	9.
1.01	10.25	125	.07	.05	.02	20.	1.01	22.25	269	.02	.02	.00	9.
1.01	10.30	126	.07	.05	.02	20.	1.01	22.30	270	.02	.02	.00	9.
1.01	10.35	127	.07	.05	.02	20.	1.01	22.35	271	.02	.02	.00	9.
1.01	10.40	128	.07	.05	.02	20.	1.01	22.40	272	.02	.02	.00	9.
1.01	10.45	129	.07	.05	.02	20.	1.01	22.45	273	.02	.02	.00	9.
1.01	10.50	130	.07	.05	.02	20.	1.01	22.50	274	.02	.02	.00	9.
1.01	10.55	131	.07	.05	.02	21.	1.01	22.55	275	.02	.02	.00	9.
1.01	11.00	132	.07	.05	.02	21.	1.01	23.00	276	.02	.02	.00	9.
1.01	11.05	133	.07	.05	.01	21.	1.01	23.05	277	.02	.02	.00	9.
1.01	11.10	134	.07	.05	.01	21.	1.01	23.10	278	.02	.02	.00	9.
1.01	11.15	135	.07	.05	.01	21.	1.01	23.15	279	.02	.02	.00	9.
1.01	11.20	136	.07	.05	.01	21.	1.01	23.20	280	.02	.02	.00	9.
1.01	11.25	137	.07	.05	.01	21.	1.01	23.25	281	.02	.02	.00	9.
1.01	11.30	138	.07	.05	.01	21.	1.01	23.30	282	.02	.02	.00	9.
1.01	11.35	139	.07	.05	.01	21.	1.01	23.35	283	.02	.02	.00	9.
1.01	11.40	140	.07	.05	.01	21.	1.01	23.40	284	.02	.02	.00	9.
1.01	11.45	141	.07	.05	.01	22.	1.01	23.45	285	.02	.02	.00	9.
1.01	11.50	142	.07	.05	.01	22.	1.01	23.50	286	.02	.02	.00	9.
1.01	11.55	143	.07	.05	.01	22.	1.01	23.55	287	.02	.02	.00	9.
1.01	12.00	144	.07	.05	.01	22.	1.02	0.00	288	.02	.02	.00	9.

SUM	34.45	30.19	4.26	12667.
	(875.)(	767.)(	108.)(	358.69)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	613.	146.	44.	44.	12673.
CMS	17.	4.	1.	1.	359.
INCHES		25.51	30.83	30.83	30.83
[illegible]		647.94	783.20	783.20	783.20
AC-FT		72.	87.	87.	87.
[illegible]		89.	108.	108.	108.

RUNOFF SUMMARY, AVERAGE FLOW IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES(SQUARE KILOMETERS)

	PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT FL ENL	613.	146.	44.	44.	.05
	(17.37)(	4.12)(	1.25)(	1.25)(	.14)

```
A1        ANCHUTZ TAILING DAM ID NO 31082
A2        HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
A3        25 % PMF ROUTED THROUGH RESERVOIR
B      288               5
B1       5
J        1       1       1
J1    0.25
K        0  LOC FL                       1       1       1
K1 25 % PMF INFLOW FROM LOCAL DRAINAGE AREA
M        1       2  0.3016                       1                       1
P        0    26.5     102     120     130
T                                                       -1     -78             0.3
W2            0.24
X      -10     -.1     2.5
K        1    LAKE                                       1
K1 ROUTING OF 25 % PMF THROUGH RESER JIR
Y                                1       1
Y1       1                                           -833.      -1
Y4   830.6   831.0   831.5   832.0   832.5   833.0   833.5   834.0   834.5   835.0
Y4   835.7   836.0   836.5   837.0   837.5   838.0   839.0   840.0   841.0
Y5     0.0      8.     28.     53.     83.     94.    120.    165.    225.    310.
Y5    470.    730.   1650.   3520.   6320.   9320.  16530.  26030.  36730.
$A      0.    16.4    38.0    40.0    42.0    43.5    46.4    48.7    53.3    58.0
$E    800.    820.    833.    834.    835.   835.7    837.    838.    840.    842.
$$   833.0
$D   835.7
K       99
A
A
A
A
A
```

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
 LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE* 79/07/19.
     TIME* 13.57.36.


                    ANCHUTZ TAILING DAM ID NO 31082
                    HEC-1  PHASE 1  DAM SAFETY INVESTIGATIONS
                    25 % PMF ROUTED THROUGH RESERVOIR

                                 JOB SPECIFICATION
   NO      NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
  288        0        5        0       0        0        0        0        0        0
                           JOPER     NWT    LROPT    TRACE
                               5       0        0        0

                        MULTI-PLAN ANALYSES TO BE PERFORMED
                              NPLAN= 1 NRTIO= 1 LRTIO= 1
    RTIOS=     .25


**********         **********         **********         **********         **********

                              SUB-AREA RUNOFF COMPUTATION

   25 % PMF INFLOW FROM LOCAL DRAINAGE AREA

                 ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE    IAUTO
                LOC FL        0        0        0        1        1        1        0        0

                                   HYDROGRAPH DATA
   IHYDG     IUHG    TAREA     SNAP    TRSDA    TRSPC    RATIO    ISNOW    ISAME    LOCAL
       1        2      .30     0.00      .30     1.00    0.000        0        1        0

                                     PRECIP DATA
            SPFE      PMS       R6      R12      R24      R48      R72      R96
            0.00    26.50   102.00   120.00   130.00     0.00     0.00     0.00

                                      LOSS DATA
  LROPT    STRKR    DLTKR    RTIOL    ERAIN    STRKS    RTIOK    STRTL    CNSTL    ALSMX    RTIMP
      0     0.00     0.00     1.00     0.00     0.00     1.00    -1.00   -78.00     0.00      .30

   CURVE NO =  -78.00   WETNESS =    -1.00   EFFECT CN =    78.00

                                 UNIT HYDROGRAPH DATA
                             TC=  0.00      LAG=    .24

                                    RECESSION DATA
                      STRTQ=  -10.00     QRCSN=     -.10     RTIOR= 2.50

   UNIT HYDROGRAPH 16 END OF PERIOD ORDINATES, TC=     0.00 HOURS, LAG=     .24  VOL= 1.00
   95.       335.      507.      485.      362.      210.      131.       81.       50.       31.
   19.        12.        7.        5.        3.        1.
```

```
**********          **********          **********          **********          **********

                              HYDROGRAPH ROUTING

          ROUTING OF 25 % PMF THROUGH RESERVOIR

                    ISTAQ    ICOMP    IECON    ITAPE    JPLT    JPRT    INAME   ISTAGE   IAUTO
                     LAKE        1        0        0       0       0        1        0       0
                                          ROUTING DATA
            QLOSS   CLOSS      AVG     IRES    ISAME    IOPT    IPMP             LSTR
              0.0   0.000     0.00        1        1       0       0                0

                    NSTPS    NSTDL      LAG    AMSKK       X      TSK    STORA  ISPRAT
                        1        0        0    0.000   0.000    0.000    -833.      -1

 STAGE       830.60     831.00     831.50     832.00     832.50     833.00     833.50     834.00     834.50     835.00
             835.70     836.00     836.50     837.00     837.50     838.00     839.00     840.00     841.00

 FLOW          0.00       8.00      28.00      53.00      83.00      94.00     120.00     165.00     225.00     310.00
             470.00     730.00    1650.00    3520.00    6320.00    9320.00   16530.00   26030.00   36730.00

SURFACE AREA=     0.        16.        38.        40.        42.        44.        46.        49.        53.        58.

    CAPACITY=     0.       109.       453.       492.       533.       563.       622.       669.       771.       882.

   ELEVATION=   800.       820.       833.       834.       835.       836.       837.       838.       840.       842.
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

RATIOS APPLIED TO FLOWS

OPERATION	STATION	AREA	PLAN	RATIO 1 .25
HYDROGRAPH AT	LOC FL	.30	1	807.
	(	.78)	(	22.86)(
ROUTED TO	LAKE	.30	1	121.
	(	.78)	(	3.41)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	833.00	833.00	835.70
STORAGE	453.	453.	563.
OUTFLOW	94.	94.	470.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	833.51	0.00	473.	121.	0.00	18.17	0.00

APPENDIX B

INFORMATION SUPPLIED BY OTHERS

REPORT OF THE NATIONAL LEAD STILLING BASIN WASHOUT

MADISON COUNTY, MISSOURI

LOCATION: SW¼, Sec. 16, T. 33 N., R. 7 E., Fredericktown Quadrangle.

The main dam of the stilling basin on a tributary to Saline Creek, running roughly north-south through the city of Fredericktown was reported to have been breached by overtopping at approximately 5 a.m. on 28 March 1977, (personal communication, Mr. Lyndell Seabaugh). The overtopping of the dam caused a breach by erosion in the main structure of the dam allowing stored water in the stilling basin to flow down the valley through the city of Fredericktown. Earthen material from the breach in the main dam, the small subsidiary just upstream of the main dam, and erosion of material from the stilling basin was also carried down the valley by the water stored in the basin.

Except for the breach eroded in the main dam no obvious structural damage by the quick release of water in the form of landslides, cracks, etc. were noted. The main dam appears to be in sound condition and in all probability is repairable. The subsidiary dike or dam just upstream of the main dam on top of the fill material in the stilling basin can also probably be repaired to its original condition once the flow of water from upstream sources has been intercepted.

A "fresh water lake" exists upstream of the main stilling basin that was evidently a source of fresh water during the mining operation. The dam has been breached to where the drainage from the watershed moves down through the fresh water lake into the stilling basin where it is normally discharged through a drop inlet and then routed underneath the main dam.

Continual erosion of the stilling basin materials down the valley toward Fredericktown can be expected to continue until the source of water from upstream has been interrupted and/or the dam has been repaired.

The area of the large stilling basin has been reported to be approximately 40 acres. The area impounding water on top of the stilling basin material is probably 1/2 to 1/3 of this area with the depth of water unknown. High intensity rainfall, reported to be about 6", early in the morning on the 28th, combined with high winds evidently overtopped the small retaining structure which then allowed rapid erosion of the main dam with resulting flows down the valley. The small subsidiary structure evidently failed first with erosion of the main dam being secondary. A flow of approximately 10-15 cubic feet per second (not measured) was flowing through the fresh water lake into the stilling basin and out the breach in the main dam at approximately 2:30 p.m. on the 28th of March.

The stratified material in the stilling basin appears to be of a very sandy nature, is evidently erodable but which does not flow even when saturated. Vertical walls of this material in the eroded area did not appear to be unstable.

A small stilling basin to the northwest discharges into the larger stilling basin with the large stilling basin discharging underneath the main dam to a channel to an additional stilling basin near the old mine buildings. Under normal circumstances, therefore, water discharged from the main stilling basin does not flow down the main stream through the city of Fredericktown.

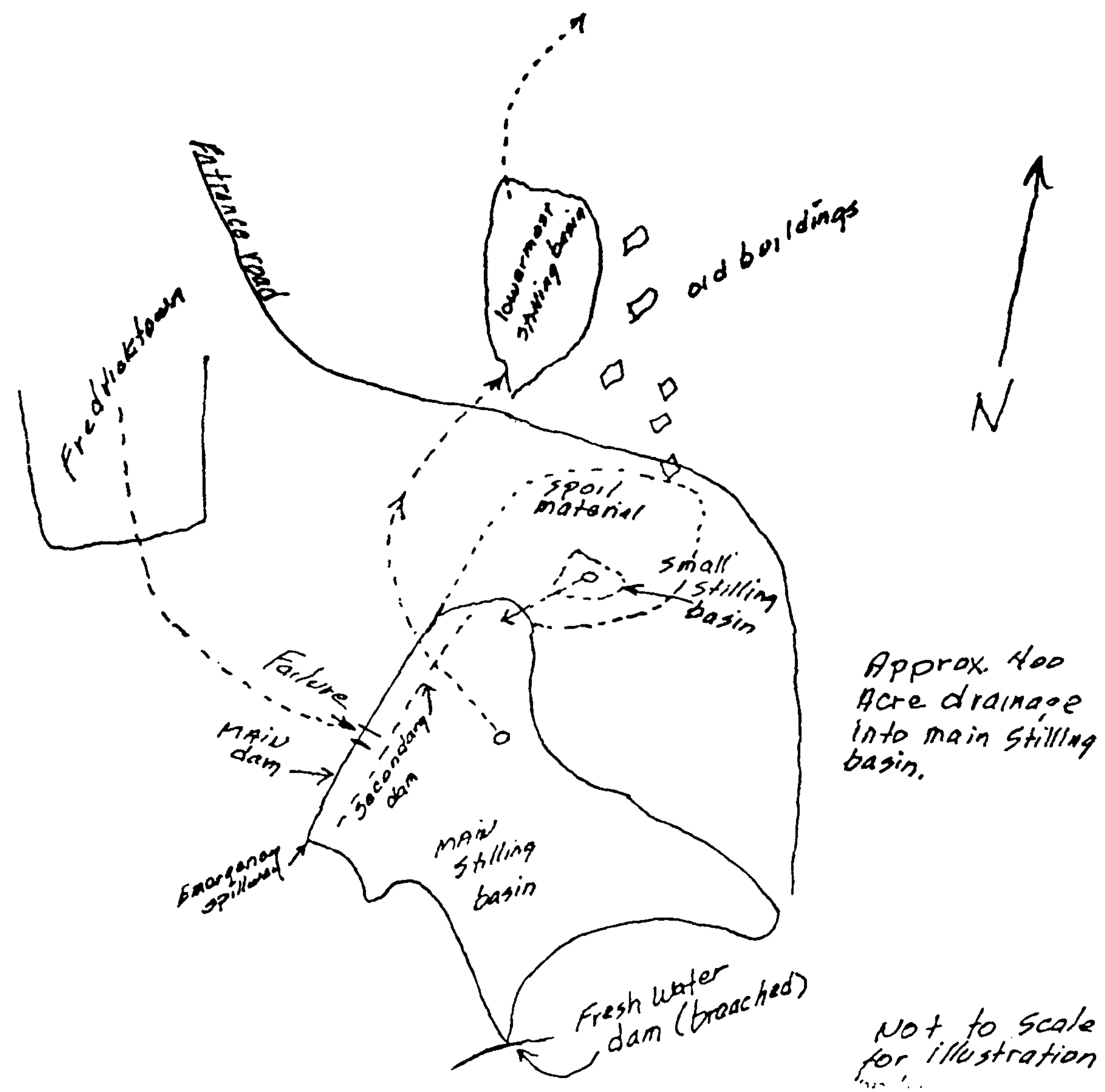
It is recommended that a hydrologic evaluation of the stilling basin, storage capacity and spillway system be made to prevent future overtopping of the main dam. As erosion of spoil piles, etc. continually fill the stilling basin, the storage capacity of the basin becomes less and less. The secondary dam just upstream of the main dam does not appear to have been designed, constructed, or maintained for long term use. An emergency spillway exists on the left abutment and its relationship to the height and condition of the secondary dam should be evaluated. A breach exists in the main dam near the right abutment that appears to have been eroded at a time not relating to the event of March 28th.

In addition, it is recommended that the lowermost basin, just downstream of the entrance road be hydrologically evaluated for its ability to withstand high intensity rainfall, as this lowermost stilling basin continually fills with material from upstream sources. The integrity of the lowermost storing basin would be in question at some future date as pipes in the dam rust out with the resultant erosion breaching the dam.

Recommend considering utilization of the fresh water dam as a flood detention structure, thus taking the burden off of the main stilling basin.

Thomas J. Dean, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
March 30, 1977

orig: Robert Lindholm
cc: Ron Bockenkamp



Approx. 400 Acre drainage into main Stilling basin.

Not to scale for illustration

April 5, 1977

NL Industries, Inc.
1221 Avenue of the Americas
New York, New York 10020

Re: Fredericktown Settling Basin

Gentlemen:

Information reaching this office indicates that early on the morning of March 28, 1977, a dam belonging to NL Industries, Inc. failed, causing the extensive flow of pollutants and water stored behind the dam into waters of the state and through Fredericktown. The reports indicate that there was substantial damage, and pollution of the waters of the state into which the material flowed.

This information also indicates that the dam in its present state could constitute a public nuisance which should be abated at the earliest possible time. In addition, it appears that until the dam is repaired adequately, there will be a continual flow of water contaminants from the settling basin into waters of the state, thus constituting violations of Chapter 204 of the Revised Statutes of Missouri.

We are at present conducting further investigations to see whether further action by this office is necessary. However, we do believe that you should take the earliest possible action to abate any public nuisance which may exist and eliminate violations of the Missouri Clean Water Law. I would appreciate being advised concerning your intentions with regard to this settling basin.

Most sincerely,

JOHN ASHCROFT
Attorney General

cc: Carolyn Ashford
Thomas J. Dean
J. Hadley Williams

25

ENGINEERING GEOLOGIC REPORT ON THE SILAS DEES (FORMERLY NATIONAL LEAD TAILINGS) PONDS

MADISON COUNTY, MISSOURI 11/15/77

LOCATION: Southwest of Fredericktown on Toler Creek.

The structure investigated is an old tailings pond used by National Lead Company during the period in which the mine at this site was in operation. The structure is located southeast of the city of Fredericktown on Toler Creek. A second dam exists upstream of this structure which was a clear water impoundment. A third structure is a tailing dam to the northeast of the first structure and drains into the first or lower tailings pond through a culvert. The lower tailings pond is of primary interest here.

The lower tailings pond reportedly was breached in the 1950's and was rebuilt. This structure failed in the spring of 1977 (see previous report by Tom Dean). The structure was again rebuilt during the summer-fall of 1977, and is presently owned by Mr. Silas Dees. The dam of the tailings pond consists of an earthen embankment overgrown with trees and brush, and a dike composed principally of tailings. The dam was breached to the approximate grade of Toler Creek after the spring 1977 failure.

On November 9, 1977 the site was revisited by Jon Bennett and the undersigned to inspect the newly repaired structures. At the time of visit, the lower structure had been filled with stoney clay which was quite soft. A pipe approximately 8 inches in diameter was dribbling water as was the not quite completely filled in breach fill. A photograph labeled 1 shows Jon Bennett beside the pipe. Toler Creek showed a larger flow than the pipe and water flowing down the dam.

Above this fill were large cracks in the fill, one of which had eroded to a sag pond which was draining into it (see photograph 2). The sag ponds were particularly interesting owing to their size (see photograph 3) and lack of surface drainage into them, yet there was significant, continual discharge. Jon Bennett reported seeing air bubbles come up from the bottom of the sag ponds. The larger of the ponds discharged over the downstream side of the dam. Both of the sag ponds described discharged continually during our visit.

The tailings dike had been filled with stoney red clay. Cracks parallel to the dam axis were observed on the stoney clay fill on either side of the dam. However, only the dike has been filled with soil, the semi-consolidated "slime" or tailings which were eroded to the approximate depth of Toler Creek were not refilled. Water now stands in this rather large gap to the height of the tailings. There was no indication of the pipe which is on the downstream side of the dam. Photograph 4 shows the height of the dam at the repaired breach and the sharp drop off at the tailings water interface.

The spillway has been cleared and will conduct a small amount of water when the water height is within about four to five feet of the crest of the dam. Photographs 5 and 6 show the height and width of the spillway which empties into Toler Creek. The dam appears to be higher at the spillway than in the center of the dam (compare photographs 4, 5 and 6).

The decant structure located in the east central portion of the tailings (see map) was filled with trees, limbs and debris. A one and one half foot lateral dike across the slime pond was rebuilt conducting about one half of all surface runoff to the clogged drop inlet of the decant structure.

The upper "clear water" structure had been breached prior to the time of the spring 1977 lower dam failure. The breached area has been since filled in. The limits of the breached area and former crest of the dam are delineated by vegetal growth and small trees which have been covered by newly laid stoney red clay.

The slopes are steep on either side of the structure. There is little evidence of construction work near the base of the dam.

The spillway is quite long in that it winds above the south shoreline. It is choked with many small to well established pine trees. Small slides, erosion, etc. have caused the spillway elevations to rise and fall. Three small ponds exist where the spillway race crosses small drainages.

Only a small amount of water was impounded by the structure in spite of the considerable rainfall during previous weeks.

<u>CONCLUSIONS:</u>

The lower dam allows seepage through the tailings dike and earthen embankment. The vegetal growth, saturated soils, sag ponds and other factors indicate a lack of acceptable construction practices utilized in the rebuilding of the lower dam. Given these conditions, <u>failure of the lower dam seems imminent.</u> It is recommended that an engineer experienced in dam design and construction be consulted by the owner at an early date.

The presence of vegetation covered by soil, steep slopes, overgrowth in spillway and other factors suggest that this structure may not have been built utilizing acceptable construction practices. A review of construction plans and procedures by an engineer experienced in the design and construction of dams would be in order.

Christopher J. Stohr

Christopher J. Stohr, Geologist
Applied Engineering & Urban Geology
Geology & Land Survey
November 15, 1977

PHOTO ~~m~~-129 FLOWN 1971 CROP YEAR 1.23

278

ADDENDUM TO FREDRICKTOWN, nee NATIONAL LEAD, nee DEES TAILINGS DAM

MADISON COUNTY, MISSOURI

Site visit on 7 February 1978 by T. Dean, G. St. Ivany, and Jim Williams, Div. of Geology and Land Survey, and Jon Bennett, City Administrator, Fredericktown, Mo. Sketch of site on Figs. 1 and 2 attached.

The gorge that had eroded after the 1977 failure is now plugged with fill dirt. This gorge has an approximate maximum depth of 35 feet. The dike averages 4-5 feet high except for the 35 foot high fill in the gorge. The gorge has been eroded to the downstream floodplain level. The material filling the gorge is tailings and dirt. Slopes are 1½:1 to 1 3/4:1. The crest width is 10 feet. Cracks are developing in the fill.

The sag pond behind the gorge fill is partially filled. Dirt previously dumped into the old breach of the sag pond has been partially removed to allow drainage from the sag pond.

A pipe discharge at the base of tailings at floodplain level was observable. This 8-inch pipe was placed end to end-not coupled. Water seeps around the pipe. The extent and means of placement of the pipe back under the filled gorge are unknown. The gorge is one-half to two-thirds filled with water.

The drop inlet (decant inlet) is 2 feet above the level of the fill at the gorge. The decant is partially filled with broken timber. The discharge pipe appears to be 4 feet in diameter. It's condition is unknown.

The emergency spillway at the left of the main stilling basin has 3 feet of freeboard below the decant inlet. This is based on hand level observation.

The upstream fresh water dam breach reportedly has been filled by end dumping (Pers. Comm.) off the edges of the crest of the breached dam. The contact between the old and new dirt is steep. However, no differential settlement has occurred. The fill dirt is a gravelly silty clay. The fill was completed in October, 1977.

The spillway is a tortuous ditch with trees and brush that eventually discharges downstream of the main stilling basin. It is a "V" shaped ditch, 20 feet at the top of the "V". The dam has 3 feet of freeboard at the high point of the ditch spillway. This is some 600 feet from the inlet. Here the spillway could also breach and discharge to the main stilling basin.

The hazards in order of priority are:

1) Collapse of fill across the 35-foot gorge with catastrophic discharge of water from the gorge and main stilling basin.

2) Differential settlement and failure of fill dirt placed in the breach of the upstream fresh water dam.

3) Failure of decant spillway due to plugging.

4) **Problem of the** fresh water dam spillway to handle flood discharges. **Approximate calculations** indicate spillway could not carry peak runoff from a 25 year **storm. However,** a calculated storm has not been routed through the spillway. **Also, the dam has** 5 feet of freeboard. Thus, this storage together with spill**way capacity** places overtopping possibilities as the least of the hazards at the **Fredericktown** Tailings Ponds.

The collapse of the gorge fill is likely to occur. The first intense rain this **spring could** easily cause that. Damage in Fredericktown would be significant.

Dr. J. Hadley Williams, Chief
Applied Engineering & Urban Geology
Geology & Land Survey
February 14, 1978

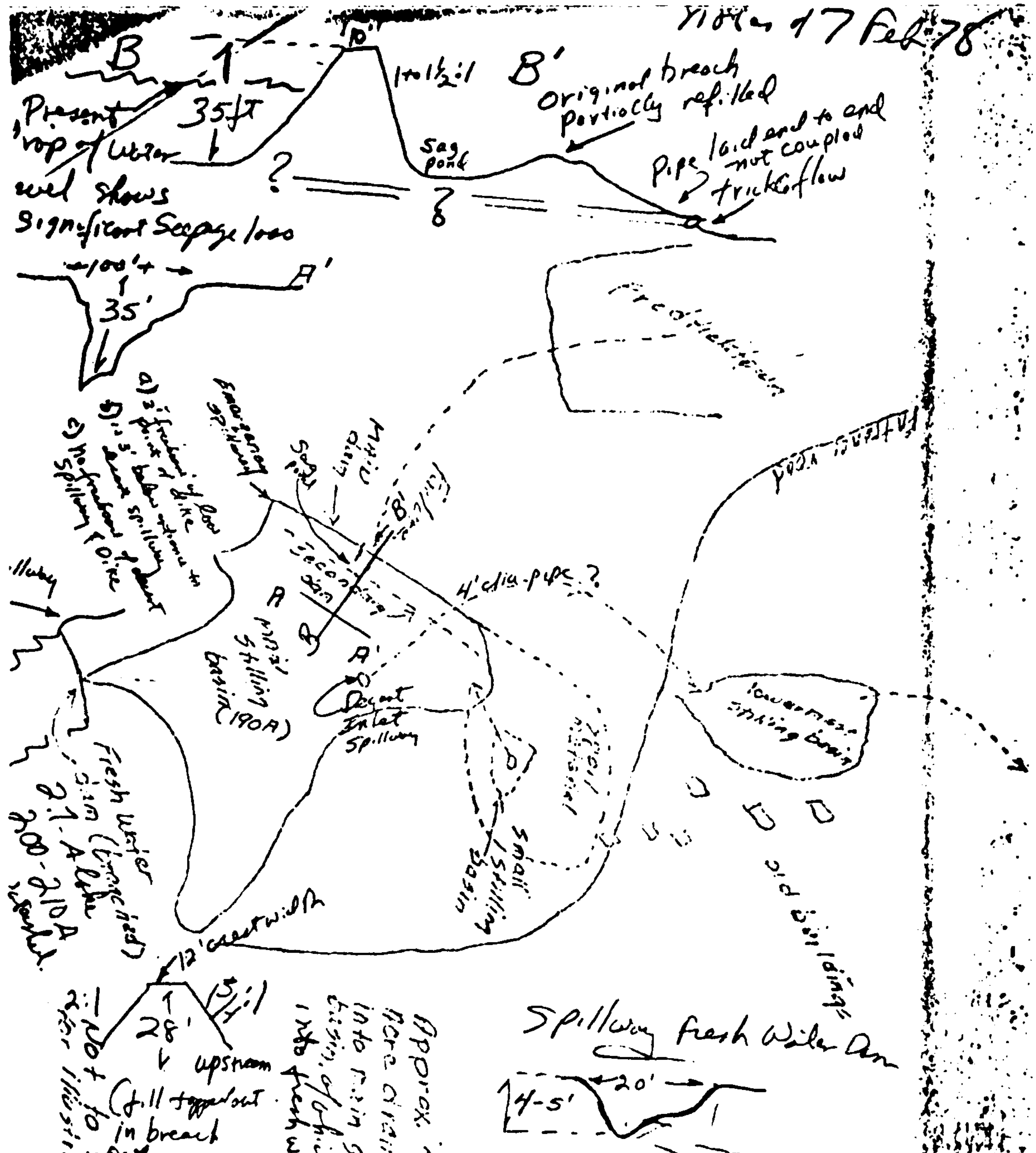

17 Feb 78
B
B'
35 ft
10'
1 to 1½:1
Original breach partially refilled
Present top of water level shows significant seepage loss
Sag pond
Pipe laid end to end not coupled trickle flow
100'±
35'
A'
Emergency Spillway
Main dam
Main Stilling basin (190A)
Decant Inlet Spillway
4' dia-pipe ?
Small Stilling basin
Lowermost Stilling basin
Fresh Water dam (Compacted) 27-A like 200-210A
12' crest width
2:1
28'
upstream
(fill topped out in breach Oct. 1977)
Not to scale for illustration
Approx. 40 acre drainage into main Stilling basin of which 200-210 into fresh water lake
Spillway Fresh Water Dam
4-5'
20'
old building

Fig 1

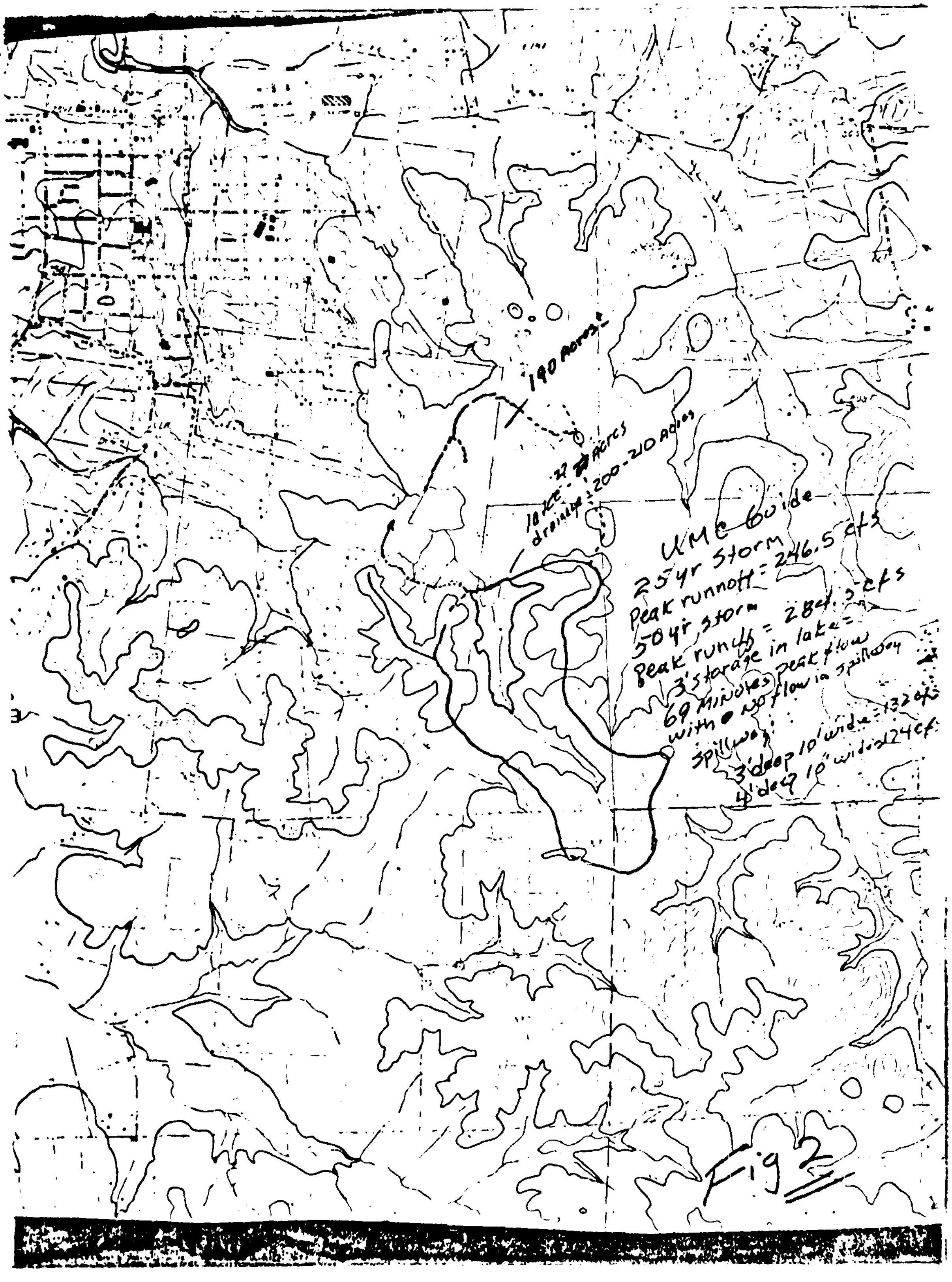
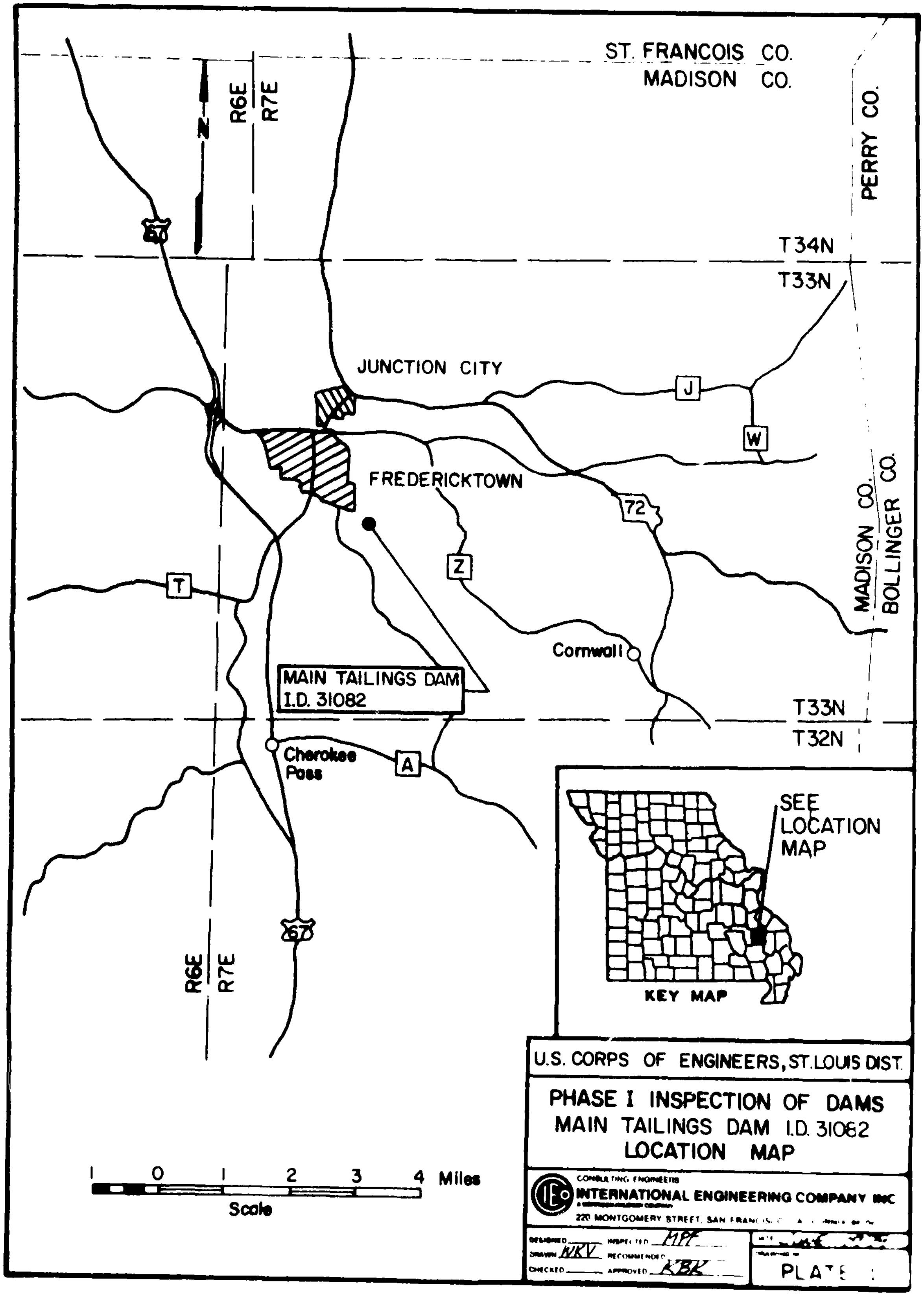

190 Acres ±
lake 22 Acres
drainage: 200-210 Acres
UMC Guide
25 yr Storm
Peak runnoff = 246.5 cfs
50 yr storm
Peak runoff = 284.5 cfs
3' storage in lake = 69 Minutes peak flow with no flow in spillway
spillway:
3' deep 10' wide = 132 cfs
4' deep 10' wide = 224 cfs

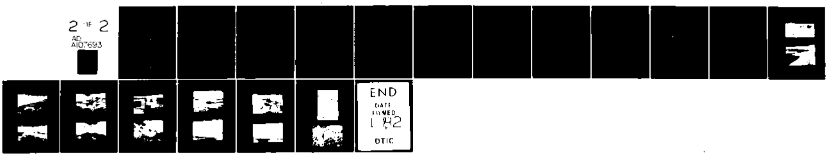
Fig 2

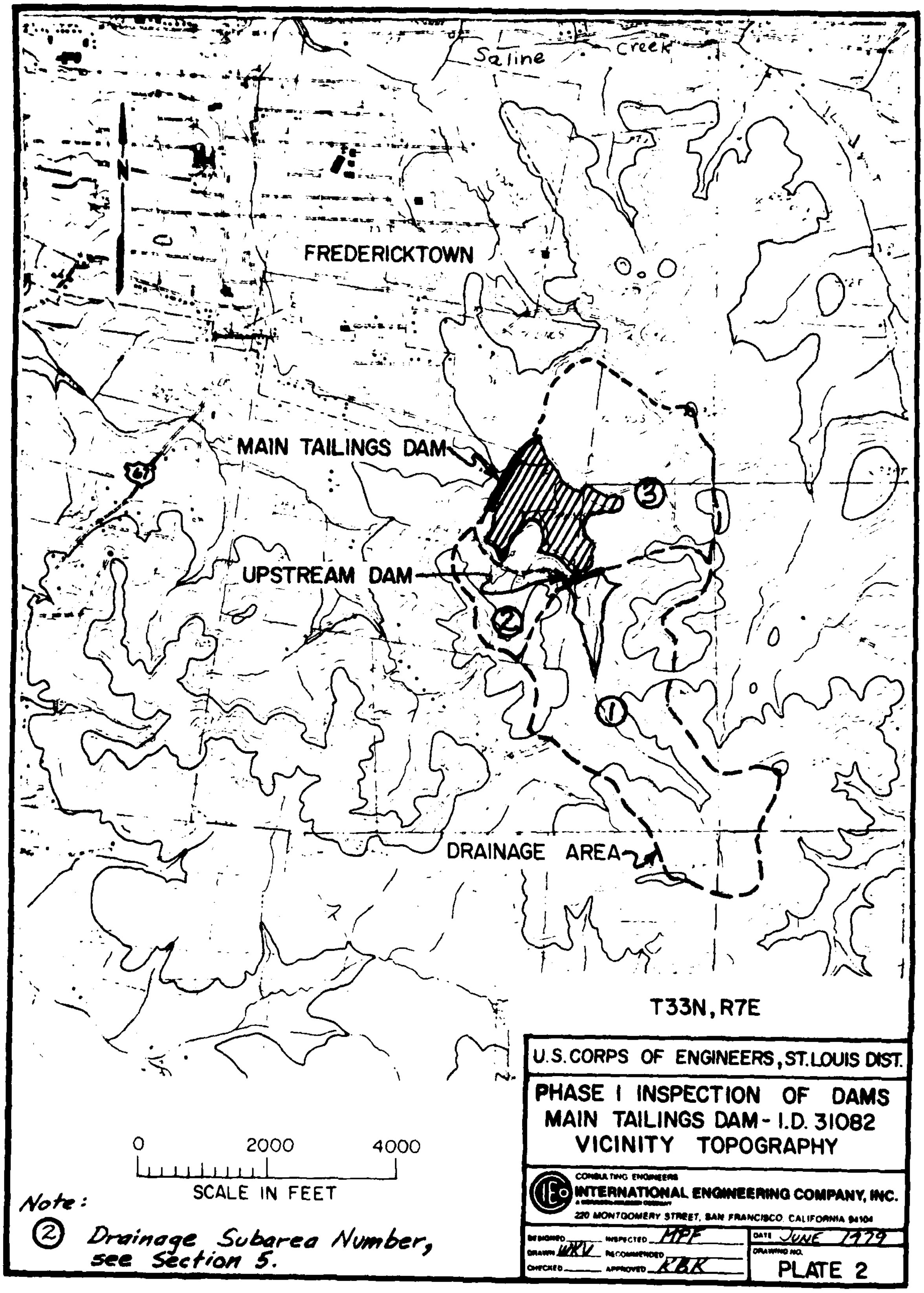


ST. FRANCOIS CO.
MADISON CO.
PERRY CO.
N
R6E
R7E
67
T34N
T33N
JUNCTION CITY
J
W
FREDERICKTOWN
72
Z
T
MADISON CO.
BOLLINGER CO.
Cornwall
MAIN TAILINGS DAM
I.D. 31082
T33N
T32N
Cherokee Pass
A
67
R6E
R7E
SEE LOCATION MAP
KEY MAP
1 0 1 2 3 4 Miles
Scale
U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.
PHASE I INSPECTION OF DAMS
MAIN TAILINGS DAM I.D. 31082
LOCATION MAP
CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY INC
DESIGNED
DRAWN WKV
CHECKED
INSPECTED
RECOMMENDED
APPROVED

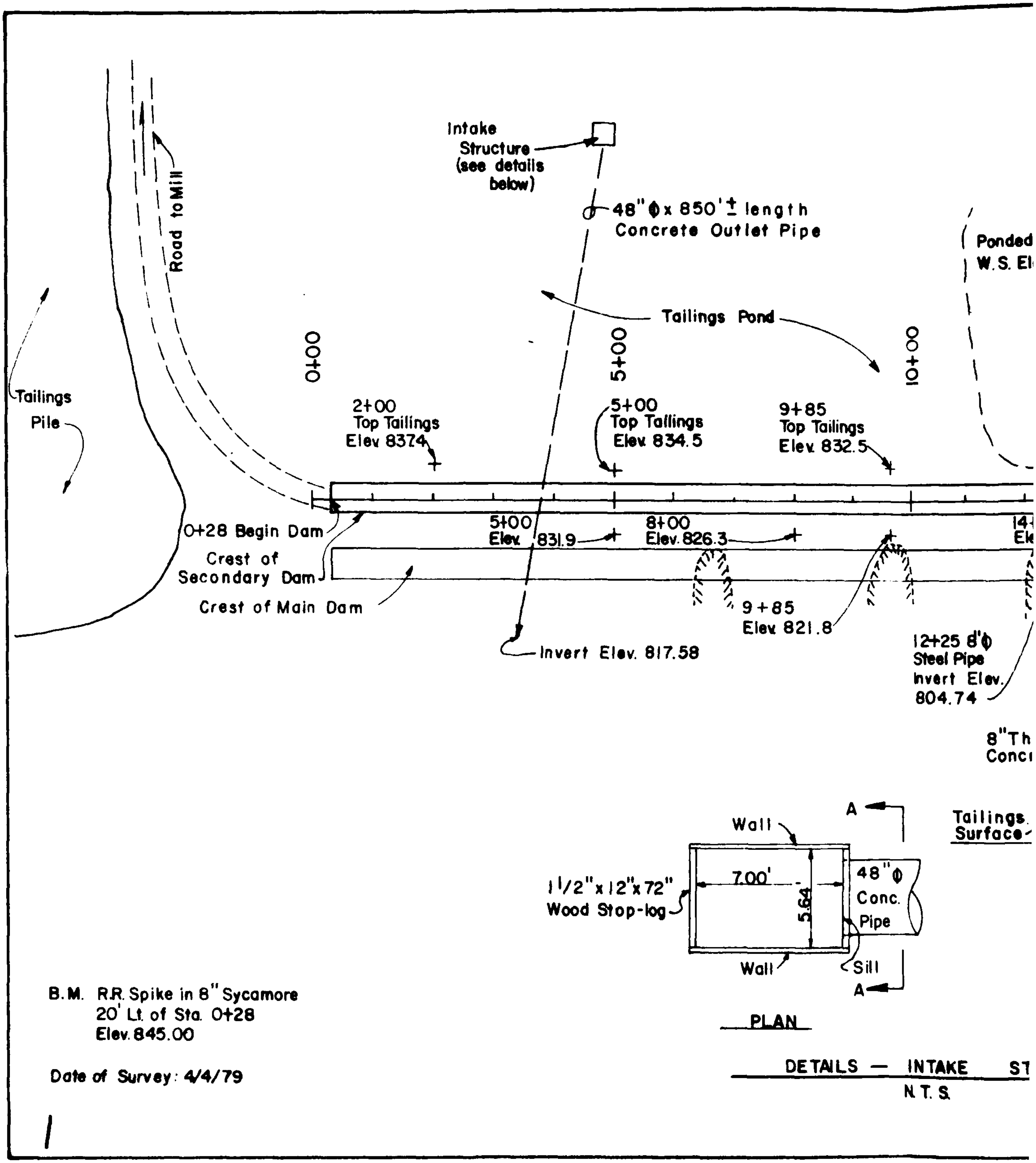
AD-A107 693 INTERNATIONAL ENGINEERING CO INC SAN FRANCISCO CA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. MAIN TAILINGS DAM (MO 31082), MISS--ETC(U)
JUN 79 K B KING, M P FORREST, D R SANDERS DACW43-79-C-0037

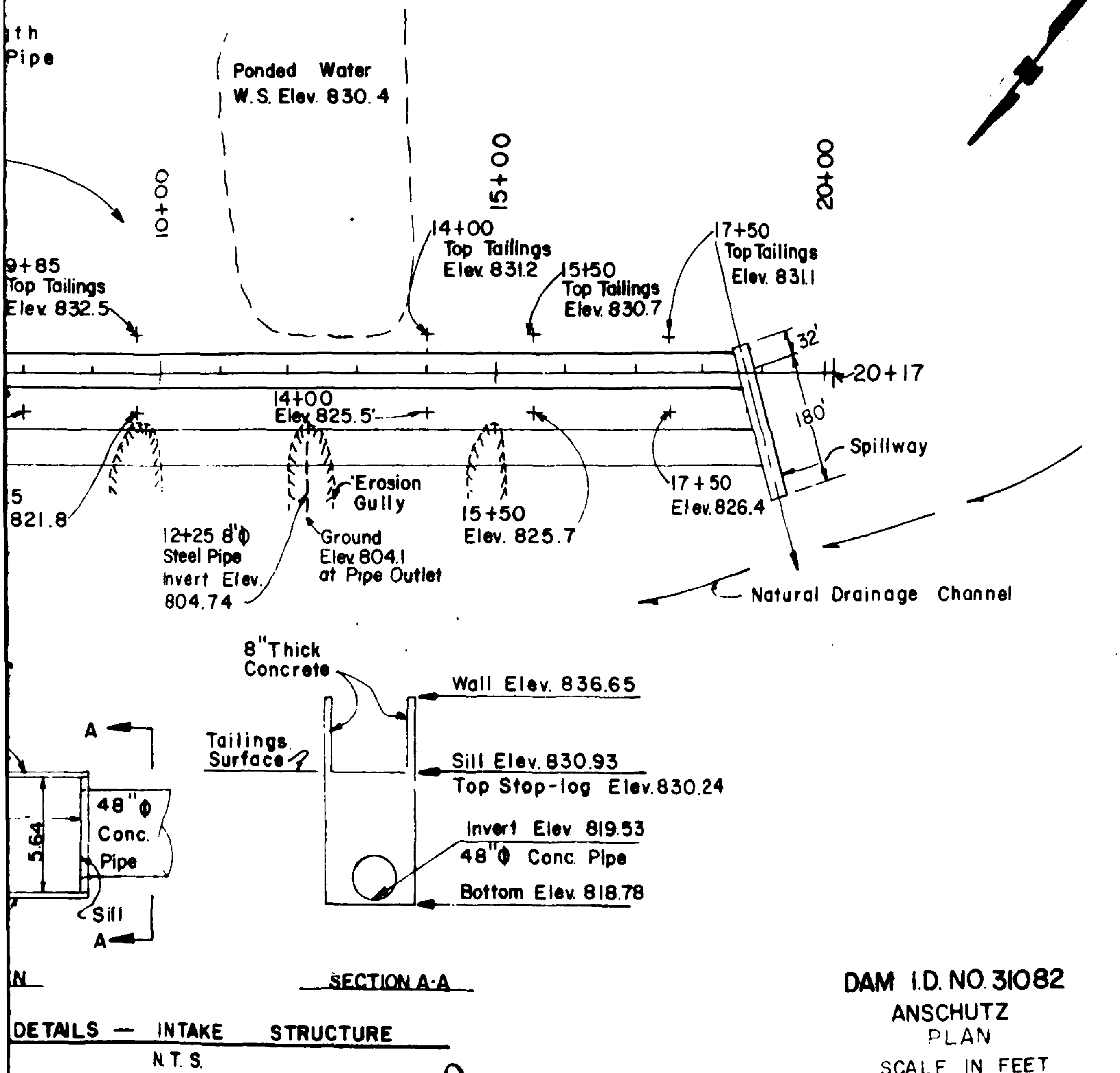
UNCLASSIFIED NL





Note:
② Drainage Subarea Number, see Section 5.

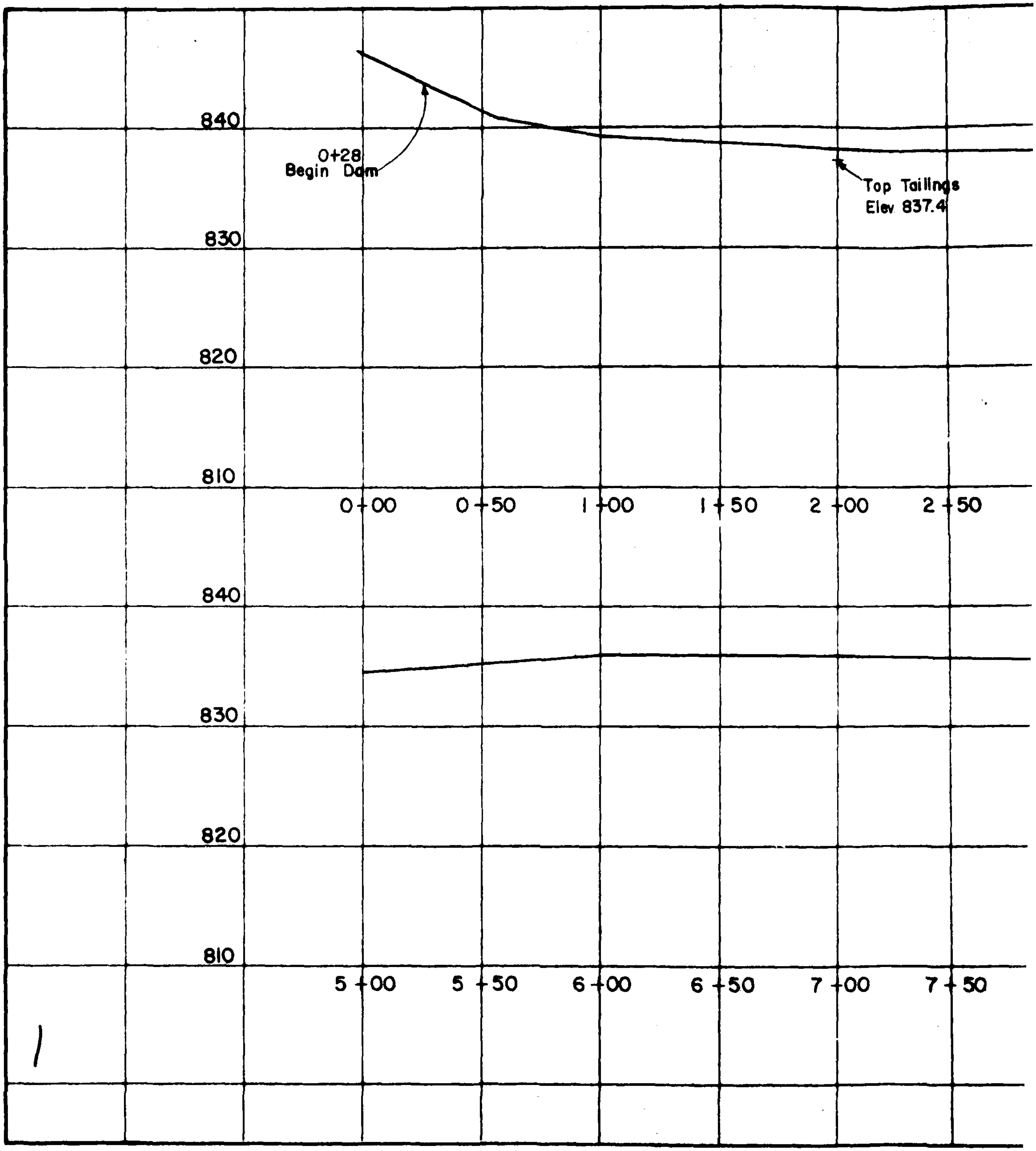

Intake Structure (see details below)
Road to Mill
48" Φ x 850'± length Concrete Outlet Pipe
Ponded
W.S. El
Tailings Pond
Tailings Pile
0+00
5+00
10+00
2+00 Top Tailings Elev 837.4
5+00 Top Tailings Elev 834.5
9+85 Top Tailings Elev 832.5
0+28 Begin Dam
5+00 Elev 831.9
8+00 Elev 826.3
Crest of Secondary Dam
Crest of Main Dam
9+85 Elev 821.8
Invert Elev. 817.58
12+25 8" Φ Steel Pipe Invert Elev. 804.74
8" Th
Conc
A
Tailings
Surface
Wall
7.00'
5.64'
1 1/2" x 12" x 72" Wood Stop-log
48" Φ Conc. Pipe
Sill
PLAN
B.M. R.R. Spike in 8" Sycamore
20' Lt. of Sta. 0+28
Elev. 845.00
Date of Survey: 4/4/79
DETAILS — INTAKE ST
N.T.S.

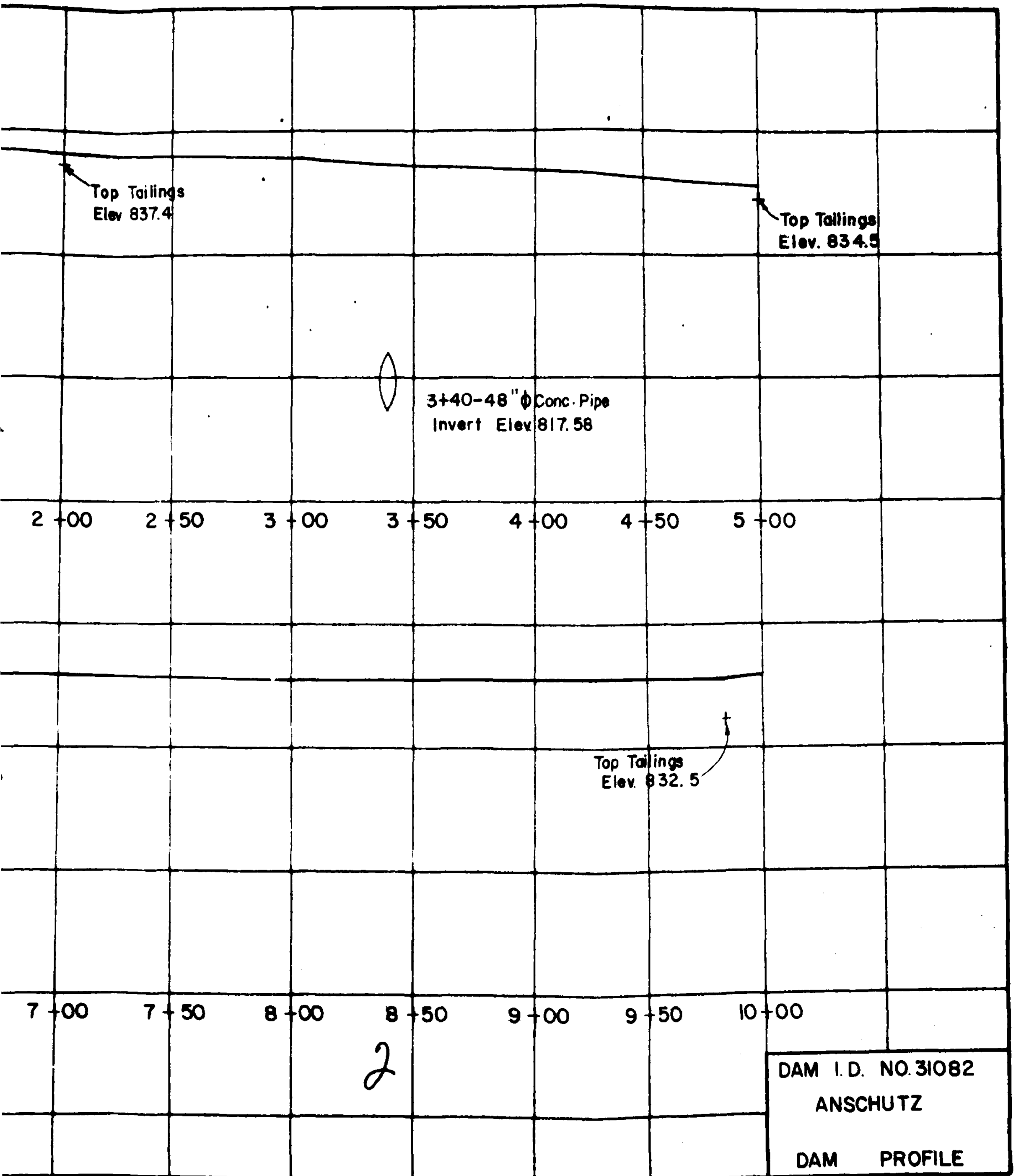


2

DAM I.D. NO. 31082
ANSCHUTZ
PLAN
SCALE IN FEET
200 100 0 200

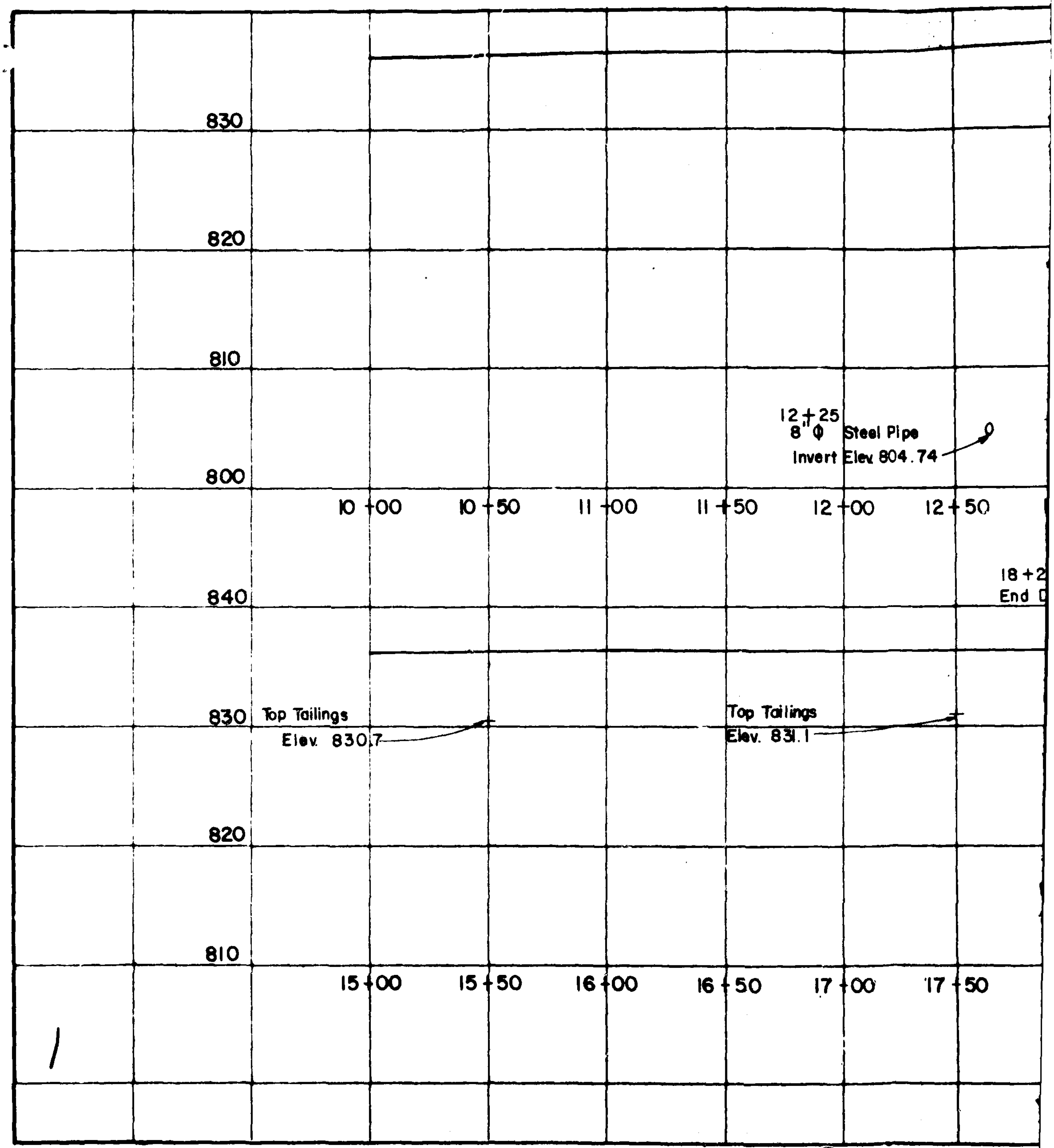
PLATE 3


840
0+28
Begin Dam
Top Tailings
Elev 837.4
830
820
810
0+00
0+50
1+00
1+50
2+00
2+50
840
830
820
810
5+00
5+50
6+00
6+50
7+00
7+50

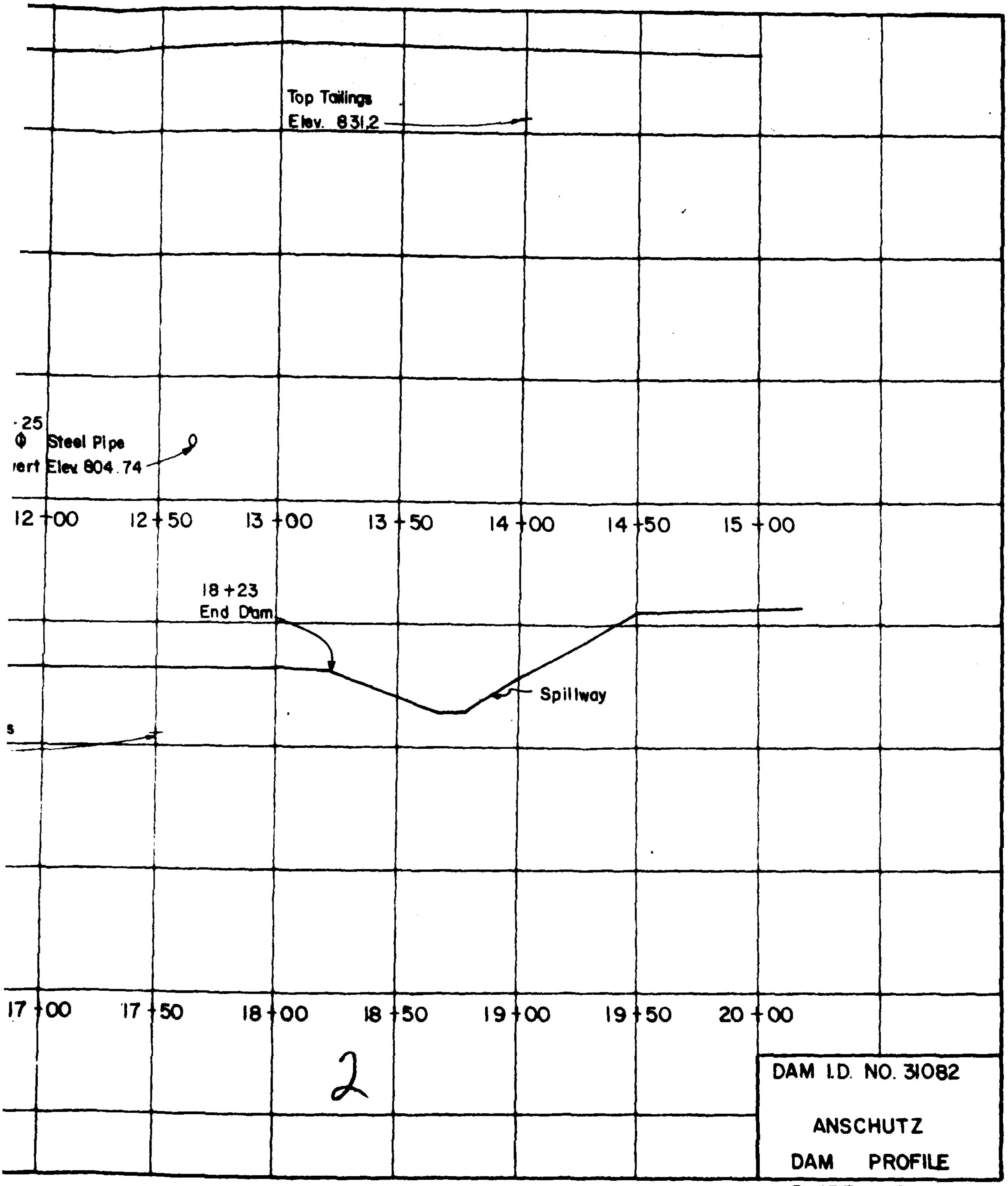


DAM I.D. NO. 31082
ANSCHUTZ
DAM PROFILE

PLATE 4A



830
820
810
12 + 25
8" Φ Steel Pipe
Invert Elev. 804.74
800
10 + 00
10 + 50
11 + 00
11 + 50
12 + 00
12 + 50
18 + 2
End D
840
830
Top Tailings
Elev. 830.7
Top Tailings
Elev. 831.1
820
810
15 + 00
15 + 50
16 + 00
16 + 50
17 + 00
17 + 50

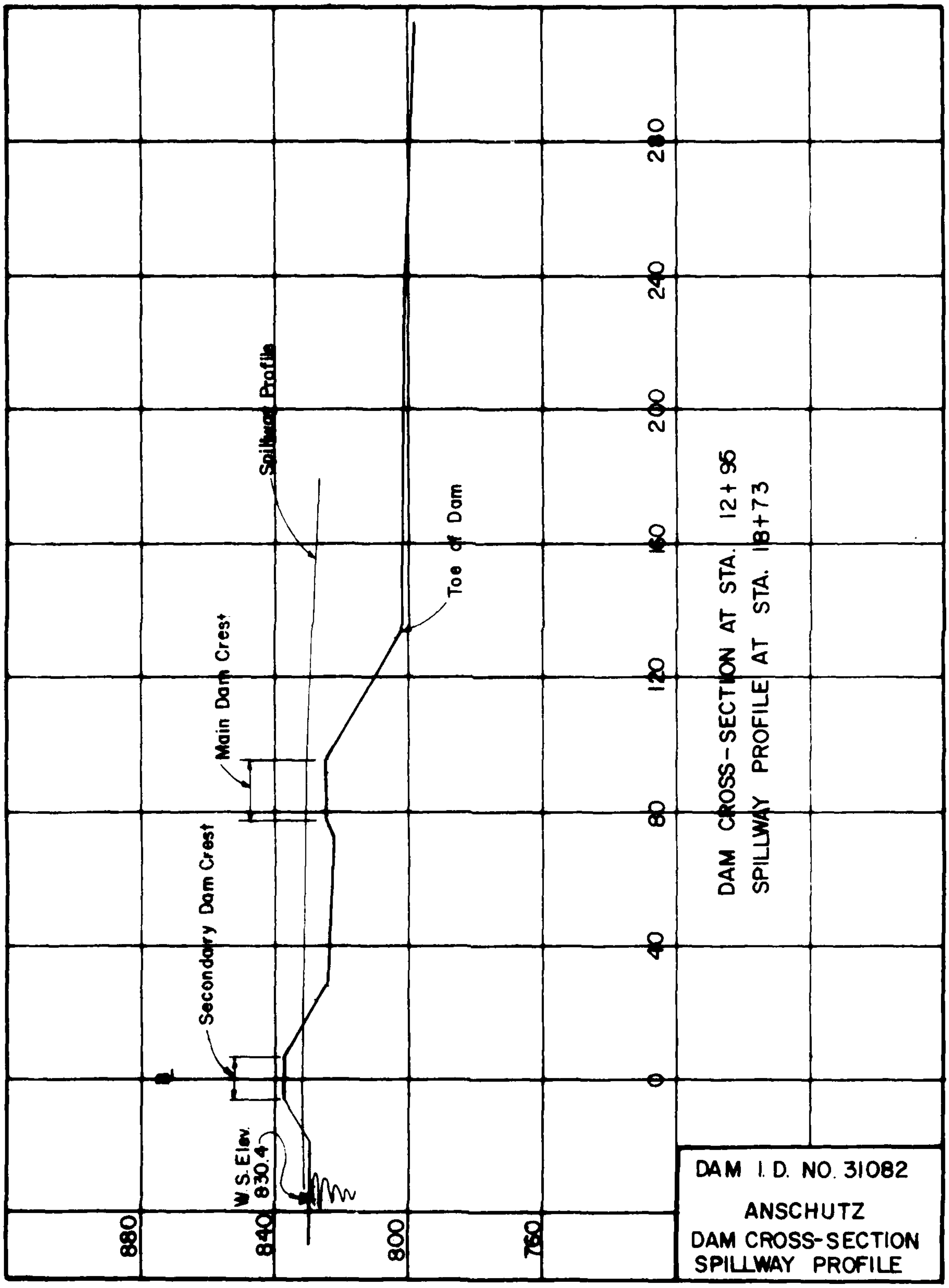


DAM I.D. NO. 31082

ANSCHUTZ

DAM PROFILE

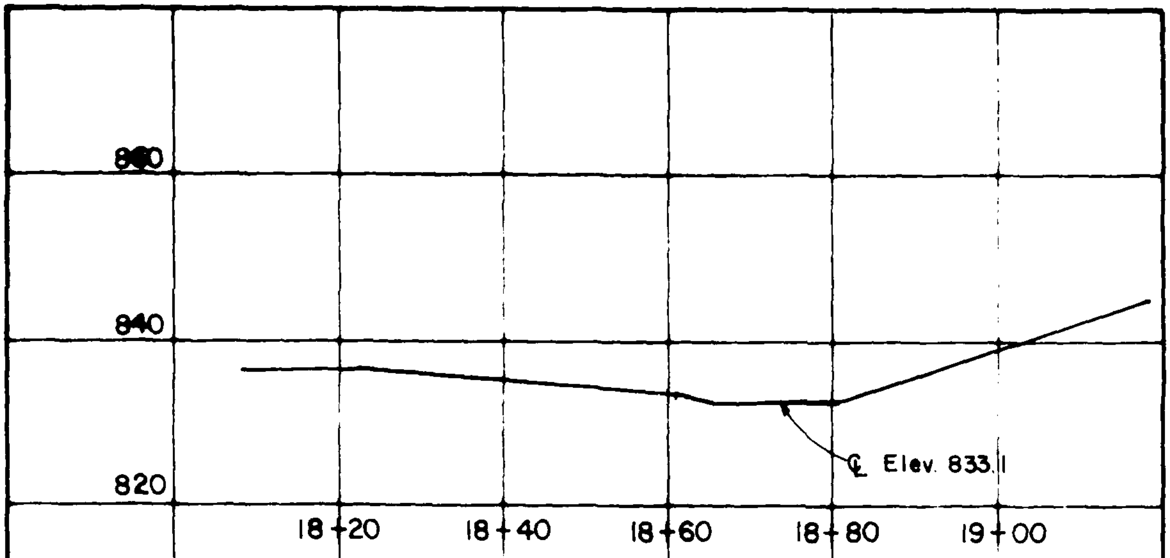
PLATE 4 B



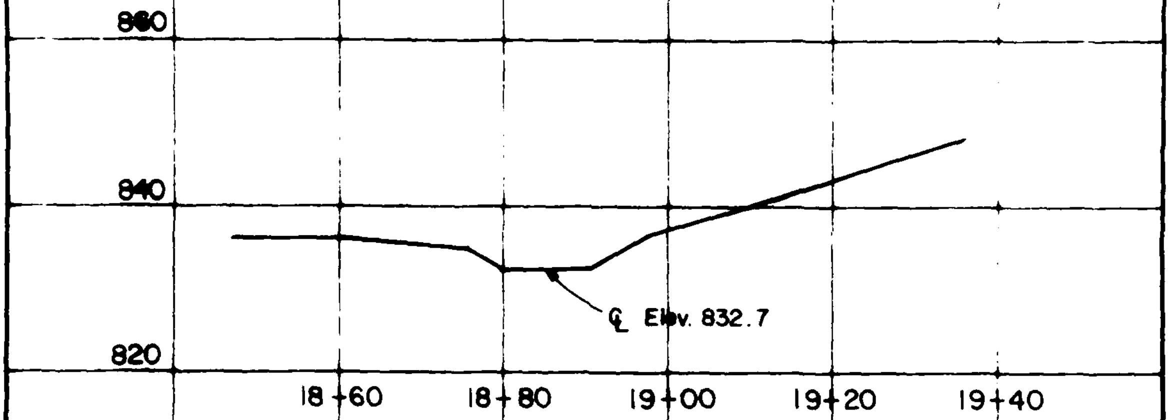
DAM I.D. NO. 31082

ANSCHUTZ
DAM CROSS-SECTION
SPILLWAY PROFILE

PLATE 5



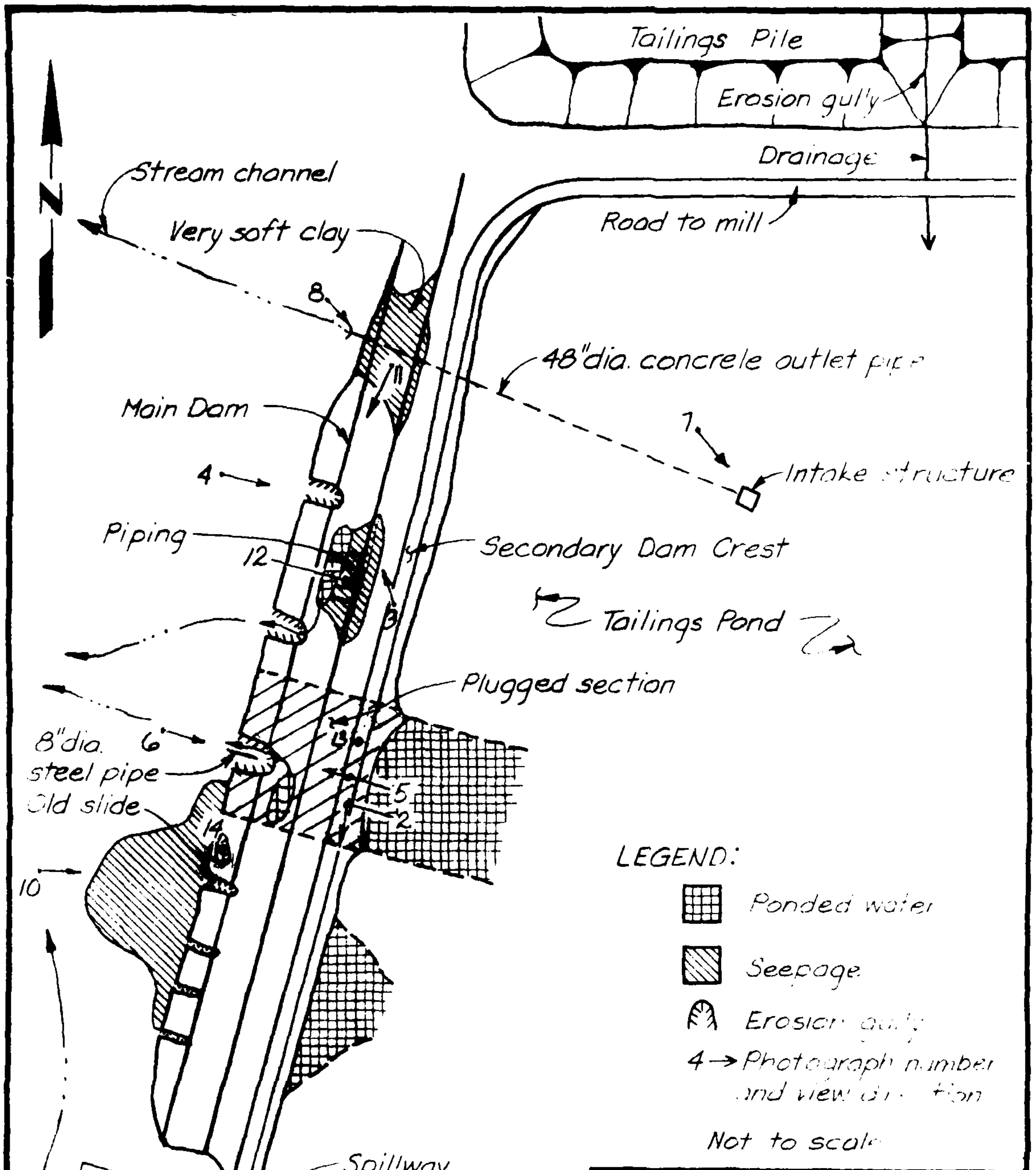
SPILLWAY CROSS-SECTION AT 7' LT. OF ℄
(Looking Upstream)



SPILLWAY CROSS-SECTION 20' RT. OF ℄
(Looking Upstream)

DAM I.D NO. 31082
ANSCHUTZ
SPILLWAY
CROSS-SECTIONS

PLATE 6



U.S. CORPS OF ENGINEERS, ST. LOUIS DIST.

PHASE I INSPECTION OF DAMS
MAIN TAILINGS DAM - I.D. 31082
PHOTOGRAPH LOCATION MAP

CONSULTING ENGINEERS
INTERNATIONAL ENGINEERING COMPANY, INC.
220 MONTGOMERY STREET, SAN FRANCISCO, CALIFORNIA 94104

DESIGNED	INSPECTED MPF	DATE JUNE 1979	
DRAWN W.K.V.	RECOMMENDED	DRAWING NO.	
CHECKED	APPROVED KBK	PLATE 7	

PHOTOGRAPH RECORD

MAIN TAILINGS DAM - I.D. NO. 31082

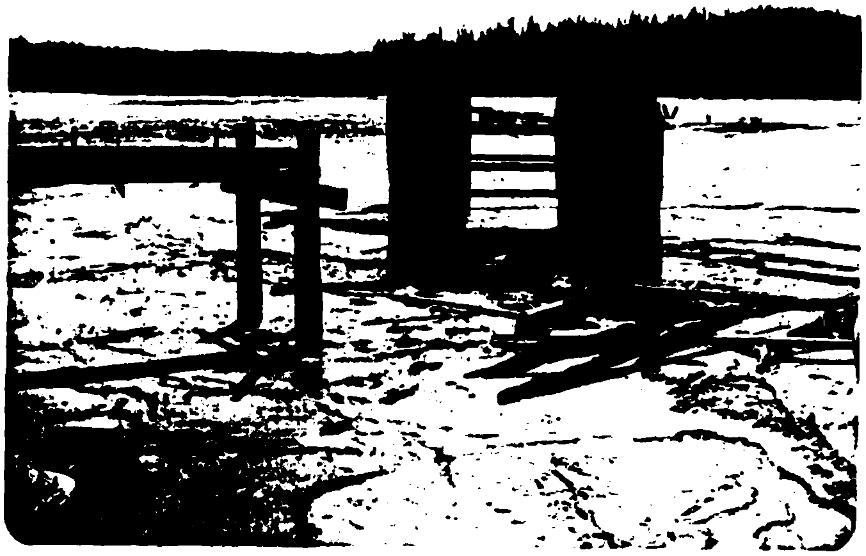
Photo No.	Description
1.	View of secondary dam crest from left abutment. Trees and brush (left side of photo) are growing from the downstream face of the main dam. The upstream end of the spillway is in the foreground.
2.	View of upstream face of secondary dam toward the left abutment. The left end of the section repaired with a plug in 1977 is marked by the survey lath.
3.	Seepage and piping of sand tailings at toe of secondary dam.
4.	Erosion gully on face of main dam. Pale green sand tailings released during the 1977 failure of the dam are visible in foreground.
5.	View downstream toward Fredericktown. Top of erosion gully in main dam in foreground and tailings released during the 1977 failure of the dam are shown.
6.	8-inch diameter steel pipe and erosion gully on face of main dam.
7.	View of intake structure; the Upstream Dam (I.D. No. 31080) is in the background at the upper end of the tailings pond.
8.	Downstream end of 48-inch diameter concrete outlet pipe.
9.	View downstream in spillway channel.
10.	Seepage at toe of main dam.
11.	Seepage and very soft clay soil condition at the toe of the dam near the downstream end of the 48-inch diameter concrete outlet pipe.
12.	Seepage and piping of sand tailings at toe of secondary dam.
13.	Cracking in crest of secondary dam. Cracks are aligned parallel to the dam crest.
14.	Old slide on face of main dam.

2

3

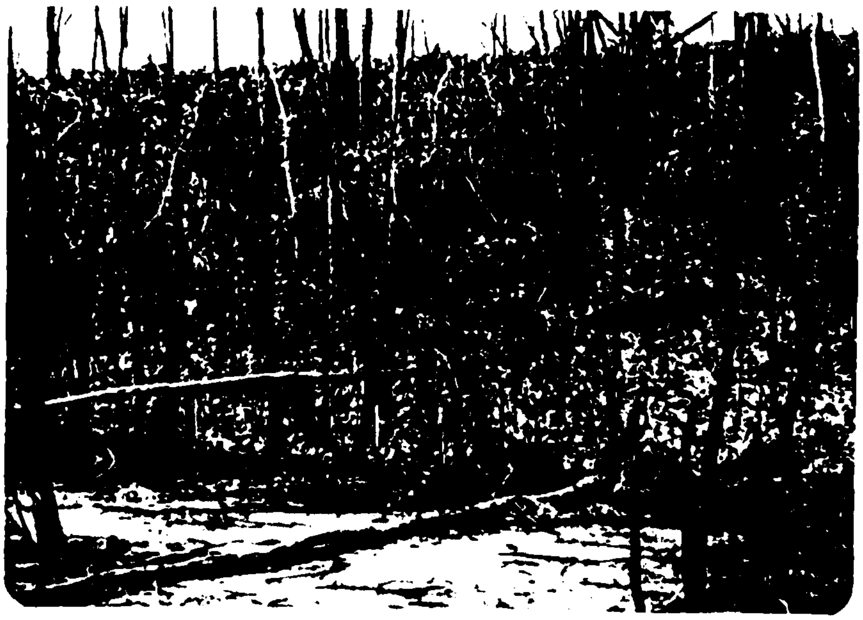
4

7



8

9



10


13


14

END

DATE

FILMED

1-82

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